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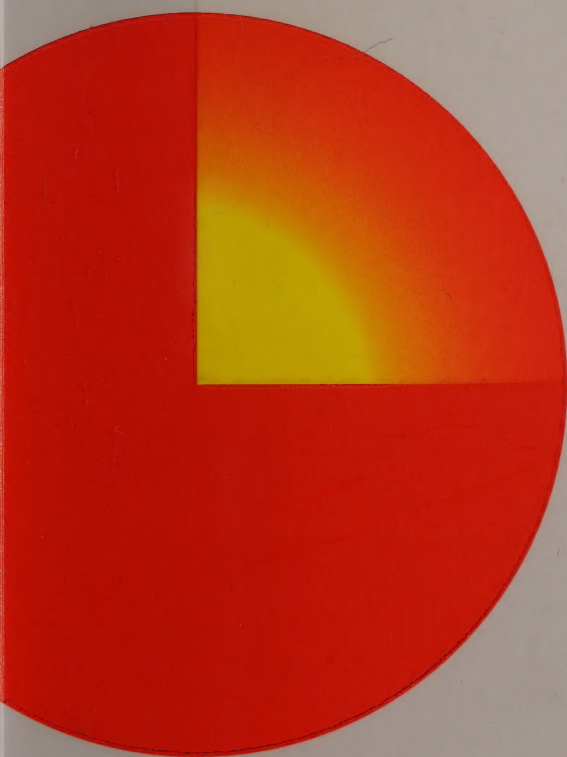
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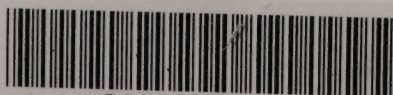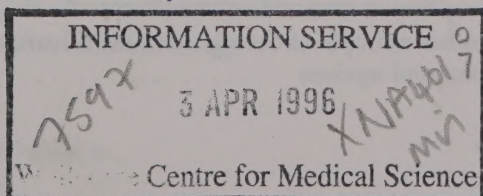
The Ministry of Research and Information Technology 1995

Research in Perspective

White paper on a
national research strategy

Foreword

This White Paper was drawn up by a group of consultants appointed by the Ministry of Research and Information Technology in May 1995 to prepare a White Paper by August 15 1995 which should form the basis for wide-ranging discussion about a national research strategy. The following points were to be taken into consideration:

overall objectives

objectives derived from these

the structure and content of the research system

a framework for prioritising and realising the objectives

continued work on creating strategy

It was the express wish of the Ministry of Research and Information Technology that the White Paper should pay attention to a number of overall objectives for the national research strategy. These included:

ensuring quality and relevance in Danish research

ensuring efficient interaction between research, trade and industry, and the rest of the system of expertise

ensuring that Danish research priorities are appropriate in an international context

improving the social anchoring of research and popular interest in matters pertaining to research

The group of consultants consisted of:

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Lene Rasmussen, Principal, the Danish Basic Research Foundation. *Secretary*

The White Paper is a step on the way towards a national strategy. Its point of departure can be found in part in earlier enquiries and plans, the 1987 and 1994 OECD evaluations, the Government's reports on research policy and proposals for strategies in individual areas. The White Paper, without doubt, reflects the composition of the group of consultants and it makes no attempt to provide a complete description of the world of research. It is our intention that this White Paper should be used as part of the basis for future work which in the course of the next year should lead to the first national strategy for research.

Hellerup, August 14 1995

Peder Olesen Larsen

Summary

Research in Perspective is a first attempt to describe a basis for discussing the nature of a national strategy for research in Denmark and to propose how such a strategy might be arrived at.

Research flourishes where all engaged in it have freedom and responsibility, tasks and duties. A national strategy should be formulated accordingly and the national Danish system for research should form a unity.

Although a national strategy must not become a "master plan" drawn up centrally or a straitjacket on research, a laissez-faire attitude would not work either.

We must make sure we can establish the community's research needs, while also ensuring that the quality of Danish research meets international standards. Research funds must be used sensibly: total Danish research spending in 1993 was DKK 15.7 billion, of which public funds provided DKK 6.5 billion. These are substantial sums of money.

Other countries draw up national research strategies and Denmark must do the same, not merely because it is done elsewhere, but because research has become an important means of maintaining a good international position. Danish research must make its contribution to ensuring that Denmark does not become a peripheral area.

The White Paper is based on these views which are described in greater detail in Chapter 2 (page 10).

The core of the White Paper comprises six general statements on research.

Research is part of the national culture, being integral to and influenced by Danish society.

Research is conducted for the sake of the community as a whole, and not for the sake of the researcher or research itself.

All research has objectives within either the research community or society as a whole.

Research must meet needs; its quality is crucial to its ability to do so.

Research policy and administration must have consideration for the complexity of the research system.

Decisions are and must be taken at many different levels of the research system.

A simple national strategy would lay down the community's research wishes and needs. On this basis it would also contain priorities and distribution of funds. But such a strategy would not work unless it went on to encompass the structure of the research system and the wishes and potentials of the researchers themselves. Only then could it cover the whole of the research system, and also have an effective impact on the research.

Money is not always the solution but too much saving can be hazardous.

A simple strategy could start by deciding how new funds should be spent, although it should still be possible to employ the strategy should the economy stagnate or cuts be needed. Its use should ensure that it is possible to get the best and the most research for the money available. In resolving research problems, more money does not solve everything, while too much saving has its hazards, a possibility in Denmark should too little be spent on research. Thus as a research system gets better (with regard to quality, selection of relevant research topics and the like), this is a valid reason for increasing research funding.

The strategy has two main elements: it must identify Danish needs and research potentials, and the international challenges facing the country, as well as developing strategies for the central actors in the research system: Government ministries, universities, Government research institutes, research councils and commercial companies conducting research. Its core is discussions between the parties concerned through which they reach binding agreements that establish objectives and set priorities, and describe how to achieve these goals.

The strategy operates on the general level of research and its organisation. In principle, it is independent of the division of responsibility between Government ministries, the distribution of tasks between universities and Government research institutes, and of the design of the research advisory system.

Thus, the White Paper does not propose a simple strategy that concerns only the distribution of new funds to priority areas but a strategy for the research system as a whole. This strategy makes the necessary assessment of wishes and potential and should have an impact on the research system as a whole.

The national Danish research strategy is defined in Chapter 5 (page 28). In accordance with the Government's decision, it must encompass the whole research system, and thus all research, despite the principal emphasis of the 1994 OECD evaluation on areas of technological and natural-science research. This strategy should be a tool to be used by everyone who makes decisions in and about the research system. It is vital that it be used in this way.

The White Paper describes the foundation that is needed for the national strategy.

The overall objectives for Danish research, as outlined in Chapter 3 (page 12), are what any strategy must be built on.

The conditions that delineate research are described in Chapter 4 (page 14). All research has objectives but basic, strategic and applied research do not form clearly separate areas. Academic freedom is important, although it must be limited. But researchers must be free to follow their research and draw the conclusions to which their research leads. Research must be relevant to clients or users within or outside of the world of research, and the research must be communicated to these clients.

Society's research needs and requirements, divided into 16 subject areas, are considered in Chapter 6 (page 34).

Research possibilities and potential are considered in Chapter 7 (page 52) on the basis of a division by discipline.

The international challenge to the Danish research system is described in Chapter 8 (page 64)

The wishes and requirements confronting the individual decision-maker in the research system are described in Chapter 9 (page 68). There is special emphasis on Government ministries responsible for grants to research, universities, Government research institutes and research councils.

Private-sector wishes, requirements and expectations are described in Chapter 10 (page 78). Both the private and the public sectors must contribute to research if the national research effort is to be fully effective.

The content and form of the final strategy are described in Chapter 11 (page 84). This strategy must be arrived at by balancing wishes and needs against possibilities and potential. Its basis must be openly discussed and followed by the presentation of a proposed national strategy. Although it will be impossible for the proposal to please everybody, it must make choices and decisions. Before being finally adopted, it must be discussed openly.

A process that can lead to the adoption of a national strategy by the summer of 1996 is presented in Chapter 12 (page 96).

The national strategy must be a framework, not a straitjacket.

It is the intention that the national strategy should provide the Danish research system with an agreed framework that needs to be established through dialogue between all the parties concerned. This dialogue is vital: if successful, individual decision-makers in the research system will make use of it and, as a consequence, allow it to transform Danish research into a single entity. If the national strategy can do this, it will have proved itself to be beneficial.

Introduction

The Government has resolved that Denmark is to have a national strategy for research. Research is necessary for Denmark because it must satisfy certain needs and because public-sector research should lead to these needs being satisfied. The national strategy must ensure that Denmark gets the requisite research.

The White Paper should pave the way for discussions

This White Paper represents a step along the way to creating a research strategy rather than a national strategy as such. It proposes the overall objectives of Danish research, what a national strategy consists in, and how the *Danish* national strategy could be created. Thus the White Paper makes a proposal concerning the content and form of a national strategy while describing the specific questions and types of questions that must be answered if a national strategy is to be realised.

The Group of Consultants suggest who should answer these questions and how the answers might be obtained. Although the White Paper does not contain a timetable, a framework is proposed for the work that must be done in the coming months and year.

The idea behind the White Paper is that it should pave the way for adequate, conscious discussion that will lead to results. The objective is for the national research strategy to be binding and for it to have an impact. This implies that it should be accorded high utility value and be backed up by the parties involved: researchers, research institutions, administration, the business community and society in general. The national research strategy must be binding and operational: it must achieve significance in the world of reality.

It is the task of the politicians to make decisions regarding the proposals and suggestions contained in the White Paper and these decisions must be made on the basis of frank and open discussions. For the present it has been decided that the national research strategy should be finalised in the course of summer 1996. This means that decisions will have to be made very soon with regard to general objectives and what a national strategy should be.

The White Paper takes its point of departure in some basic views of research and regulation of research:

Research thrives when all parties involved have freedom and responsibility, tasks and duties. All parties should have objectives, and all should be involved in drawing up these objectives.

Researchers and the research system should both carry out tasks which originate externally from the surrounding society, and tasks of their own choice.

The research system is an entity within which all problems needing research are solved.

It is important to have a national strategy and the very process of finding this strategy is of value in itself.

There is neither need for a master plan nor room for laissez-faire

These views do not mean that we are either planning or would favour a master plan for Danish research, or that we would leave everything to market forces and competition.

Like the planned economy, the idea of a master plan is obsolete. Research is not suited to regulation by command. For this reason the White Paper emphasises that there are and should be decisions, and decision-makers with responsibility and powers at all levels of the Danish research system.

Nor do we favour a laissez-faire attitude: we do not believe that all research funds should be offered in free competition with a view to solving problems formulated from the top or from the outside. In the field of research this would lead to chaos, a lack of certainty that all tasks were being performed, a lack of stability in the research institutions, and too little scope for researchers to contribute their own ideas and creativity.

It is necessary to keep a distance from both extremes, and thus the White Paper contains proposals concerning competition and other regulation mechanisms and how to achieve the most favourable balance between them. The White Paper emphasises that it is essential to achieve this balance between the overall national research strategy and the strategies which decision-makers on all levels must develop and for which they must take responsibility.

The proposals contained in the White Paper are based on a conception of the nature of research, what the national strategy is concerned with. This is described in Chapter 4 (page 14), and the following chapters are based on this description.

Overall objectives for Danish research

Research is necessary to Danish society; it must make a contribution to ensuring that prosperity is maintained, and improve the population's conditions of life and the competitiveness of the country. Research is necessary for Denmark's ability and will to adjust and for the influence the country will exert on the future. Danish research should be an important part of the country's contribution to European cooperation and to leading Europe into the future. Research must do its bit to ensure that Denmark does not become a peripheral area.

A society based on knowledge

Research must help to ensure that we have a knowledge-based society; therefore it should secure knowledge and access to knowledge for all groups in society.

Research must contribute to the maintenance and further development of high levels of general health, culture and welfare for all population groups and contribute to protecting the natural basis.

Research must contribute to maintaining and developing Danish cultural identity in national and international contexts.

Research must contribute to the development of trade and industry, and contribute to ensuring efficiency and competitiveness in all areas of production.

Research quality must be enhanced in both the public and the private sectors. Danish research must be of international standards and outlook: only by making a contribution will Danish researchers receive something in return. They must participate actively in international research collaboration, including within the EU. Danish research should form the point of departure for influencing EU research strategy and ensuring active participation in EU-funded research.

The research system of the country should function as a whole consisting of active research environments. For this reason we need a common strategy for what Denmark wants from its research and for how to organise the Danish research system to realise the desired objectives. Researchers and the research system on the one hand, and on the other hand politicians, administration, the business community and the general population, must cooperate to establish a strategy. Such cooperation is a necessity for research in a system which should be open and comprehensible to researchers and users of research.

Research, because society needs it

Mutual understanding between researchers and the world around them must be enhanced. Researchers conduct research because society needs it and not for the sake of research itself. Society can only get good research when researchers are free to draw the conclusions to which their researches lead them, if they have considerable freedom of choice in tasks and methods, and, finally, if researchers are conscious of their responsibility. While the research system must be so stable that long-term work can be carried out, quality and relevance must be continuously assessed.

4. What is research?

Research is an integral part of our country's culture. Without research in Denmark, we would be unable to obtain, understand or utilise knowledge from abroad. While ensuring high educational standards and innovation in curricula, research leads to education of those new researchers who are needed in the research system itself as well as elsewhere in society. Research provides us with concrete results and gives us the impetus to develop new products, both of which are needed. Research delivers the unexpected, which is both indispensable for its own development and essential for society.

Research is a precondition for prosperity

Without research we would not have prosperity. It is essential to our spiritual and material well-being in the future. Danish research must be an independent and significant part of world research. These general statements need, however, to be amplified by a number of reasons why research in Denmark is indispensable.

Research is a part of Danish culture; it is essential for its custodianship and for it being handed on to the next generation. Research is also a part of European and global culture, and Denmark must make its contribution to ensuring the continuation of that culture.

Research carried out in Denmark is necessary to enable us to draw on the whole of the world's research. It is necessary, because unless we ourselves carry out research, we cannot fully understand and make use of the research results of others. It is also necessary, because researchers elsewhere in the world will only inform Danish researchers of their exciting results, if Danish researchers have something interesting to disclose in return.

In many areas research results from other countries can only provide guidelines. Denmark has its own culture and its own structure which are crucial to decisions in society. Where research is part of the basis of decision-making, it must often be research carried out in Denmark.

Research and good education go hand in hand. The contents of curricula must be constantly renewed and reconsidered. Here research has an important contribution to make. Society needs people who, in the course of their education, have learned about the nature of research, and consequently know how to utilise its results.

New researchers are some of the most important products of research. There is a need for new researchers who have been active at international level to further research in the public and private sectors. Peo-

ple with a research background are also needed in many other places in society.

Research can lead to the unexpected

Research is necessary to solve countless specific problems in Danish society. The private sector is particularly dependent on research results as basis for competitive production in the future. There are, however, many cases which illustrate how research aimed at solving concrete problems has led to fundamental new insights; conversely there are many examples showing how research intended to obtain new knowledge, new understanding, and new insight has in fact led to new, unexpected solutions of specific problems.

Research can lead to the unexpected. The unexpected can both change our view of the world, and be of practical importance. Good research often leads to unexpected and valuable results.

4.2. The different research concepts

All research has objectives

All research has objectives and aims for usable results. Objectives and results may lie within or outside of research itself. Research must be judged by its results.

The boundaries between basic research, strategic research, and applied research are blurred, and it is not necessary to make sharp distinctions. In most cases, applied research finds its objectives outside of research itself, although it will often produce results of significant value to research in general. Strategic research means research in areas which are, or will become, of importance some place or places in society. Basic research, with objectives within research itself, can often produce results which can be applied outside of research. Strategic research comprises a major part of our present basic research.

A national research strategy does not comprise only, or even mainly, strategic research.

A good deal of the debate on research policy has been concerned with the various concepts of research. The problems cannot, however, be solved at the drop of a hat merely by introducing precise definitions. The world of research is many-faceted; there will also be borderline cases, counter-evidence, and definitions leading to real or imaginary disagreements. Nor is it necessary to have precise definitions of the

various research concepts. It is essential, however, to emphasise that research is something special in its own right, and that it is necessary to distinguish between research and non-research. Research creates new knowledge or understanding; it is determined by its tradition and methods while simultaneously transcending its own boundaries.

Good and bad research

Although there is a risk involved in making distinctions and in grading, and mistakes are indeed made, this does not mean that the process is pointless. If distinctions are not made, chaos soon ensues. If everything can be called research, it becomes too difficult to recognise valuable research. If research can neither be called good nor bad, there is nothing to steer by.

Today there is a great deal of talk about basic research, strategic research, and applied research, and it is common to regard these concepts as being incompatible. Whereas basic research is said to be conducted in order to create new scientific insights without consideration of possible applications, applied research is claimed to be aimed at the solution of concrete problems, at practical goals and applications.

It is therefore important to make it clear that all research has objectives, and that all research is aimed at usable results. It may well be that basic research in the main sets its targets within the world of research itself, whereas applied research is aimed at objectives and applications outside the world of research. But the boundary is not at all clear. Much basic research eventually turns out to be applicable, and applied research has often made weighty contributions to the development of research as such. Researchers themselves are often in doubt as to whether they are conducting basic or applied research, and the uncertainty does not bother them in the least – except perhaps when they have to report to the statistics of research activities.

The generally accepted view is that basic research is primarily conducted in universities, whereas applied research is above all a matter for Government research institutes and private companies. In fact there is a good deal of applied research in universities, and also basic research in the outside world.

Research must be judged by its results

It is impossible to say anything about the importance, quality or degree of difficulty of research merely by describing it as either basic or applied research. All research must be judged by its results, and by the degree to which it achieves its objectives. Hence, it is necessary to know the objectives, even if one does not wish to label the research in question in one way or another.

The concept of strategic research has only recently really become part and parcel of the debate on research. In general, strategic research refers to research which is needed as a preparatory investment in areas which are, or may become, important in one or more areas in society. This research is designed to create a basis for future results which may be applied to uses outside research itself. There are good reasons for

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describing much current basic research as strategic research.

Like basic research, strategic research will often be an investment where errors and surprises are affordable and may in fact produce something good.

The desire to have a national research strategy is not connected with the concept of strategic research in the sense that the strategy should comprise only strategic research. The strategy is to comprise all research. Nor can the different kinds of research be placed in continuation of one another, meaning that basic research supplies the needs of strategic research, and strategic research delivers what is required by applied research in order to enable it to supply the R & D described below. Results, knowledge, and problems cut across the entire system.

R & D is a term describing a multitude of activities, only a few of which are related to research. The statistical record of Danish research efforts does, however, include the R & D carried out in connection with or as an extension of research. According to the official definition this is considered to be systematic effort based on the application of knowledge which has been acquired through research and/or practical experience, with a view to producing new or significantly improved materials, mechanisms, products, processes, or services.

In R & D carried out in continuation of research or in connection with research, the expected results will normally be defined in advance, and there is no room for errors. Much R & D is, however, carried out by researchers and it can be performed in the public as well as in the private sector. In the total contribution of industry to research and development, the latter will often be predominant.

Enquiries and reports are not the same as research

Researchers are frequent contributors to enquiries and reports. These may contain systematic accounts of existing knowledge and research results, and can be carried out on the basis of and with a background in research. It is necessary to distinguish between research and enquiries and reports based on research. Research should lead to something previously unknown, to new knowledge, whereas enquiries and reports relate already existing knowledge.

4.3. The relevance and dissemination of research

Research should be relevant. It must lead to results of interest to others, to users within or outside the world of research.

In general, research results should be made public in order to make them open to criticism, as well as to show the value of the researchers' work. Research can also, however, be transferred directly to well-defined users without being made public. This kind of communication is primarily employed in the private sector.

Research must be relevant. This means that its results must be of interest or importance to others. It is often said that research is unpredictable, that results cannot be foretold, because then it would not be research in the proper sense. That is true enough, but it must not serve as a pretext for rejecting considerations of relevance. It is necessary for researcher to consider whether the problems they have chosen are to the point, and whether their solutions will be of interest to anybody besides themselves.

Consequently researchers and decision-makers must be clear in their own minds why a piece of research must be carried out. Who is interested in the results? Who are the users, if any? Users may be external, from the surrounding society, or internal, from within the research community itself. Although pioneering research may not always be applied immediately, even then it is necessary to consider why it is important to carry out the research in question. It does not suffice that it may lead to something previously unknown.

Research can only be relevant if it gets through to the users. This means that the results of research should either be published and thus made publicly available, or that the research results should be passed on directly to identified users.

Considerations of relevance will often have to include an evaluation of how justified it would be to conduct this particular research in Denmark rather than elsewhere.

When research is made public, it becomes exposed to the criticism of the research community. This is of great value in itself. Publication also makes it possible to ascertain whether the researchers are doing their job properly.

Not all research can or shall be made public. Research in the private sector often has to be kept secret to prevent its exploitation by competitors. Also in the public sector, and in research carried out jointly by the public and private sectors, there may be examples of research which cannot be published. This makes it essential that the users should be known, and it implies that there are special problems involved in assessing whether the research is of adequate international quality.

4.4. Communication of research

The results of research, and the expertise and specialist knowledge of researchers must be communicated through conscious efforts.

An important part of the communication is effected by the movement of researchers from the public sector into private enterprises.

Another important part of this process is achieved by researchers

who make their knowledge available in committees, boards and councils, and contribute to reports and enquiries which form a background for political decisions.

Research can and must be used

It is not a matter of course that good research results get through to and are applied in the places where they can be of use. Nor should it be taken for granted that the researchers' expertise and their ability to obtain knowledge will be used. Even the best research system does not help a country, unless it is used properly.

That is why the communication of research must form a significant part of research efforts. Researchers must not only be fully aware of the identity of those who use their research; they must also give full consideration to how they can reach those users.

Research with objectives and users within research itself is communicated through traditional and effective channels: publication in scientific periodicals and books; conferences; personal contacts; and networking.

There may, however, be problems involved in communicating research to users outside the research system. Specifically, there are problems connected with transfer of research results to the private sector with a view to application in competitive production. The solution of these problems calls for an open and accommodating public research system; close relations between research on the one hand and the documentation and library system on the other; conscious endeavour and marketing activity.

Although not all researchers are equally good communicators, there must be methods of collaboration that ensure proper communication. Every institution is responsible for solving the problems of communication, regardless of whether, or how, individual researchers make their contributions.

To a large degree communication takes place through personal contacts, above all people moving from one place in the research community to another within or outside it. It is of paramount importance for the communication from public sector research to private enterprises, that the latter employ persons who through research, including training as researchers, are familiar with public research and have personal contacts with researchers in the public sector. The most important transfer of knowledge to the private sector is through researchers moving over, and hence new researchers represent one of the main products of public research. Mutually binding cooperation on research is also important for communication and transfer of knowledge.

Finally, significant communication of research takes place through the previously mentioned participation of researchers in committees, boards, and councils, and by their contributions to official reports and enquiries.

4.5. Academic freedom, the responsibility of researchers, and research ethics

Academic freedom is an important principle, although it is a concept that needs subtle interpretation.

The first element of academic freedom is dependent on the obligation to endorse all results which the researcher's efforts may lead to, no matter whether the researcher or his/her employer like them or not. This freedom from the obligation to reach any pre-defined results must be upheld as an unqualified demand.

The second element of academic freedom is free choice of method, a freedom that may be limited by financial considerations. But there must be no limitations caused by traditions or rigid orthodoxy in the research community.

The third element is freedom to publish the results of research. This freedom is limited, for instance by financial considerations or the wishes of employers.

The fourth element of academic freedom is freedom to choose research topics, which is limited by the employers' wishes or by the scope of the fields covered by research institutions. It is, however, a good thing for research that researchers are able to influence the formulation of tasks, and that some of the time it is possible for them to draw up problems and tackle them in their own way.

Academic freedom and the responsibility of researchers belong together. Researchers must manage their monopoly of knowledge in such a way that their knowledge is made available to society.

Researchers are responsible for what they choose to do in their research.

There must be room for both academic freedom and outside influences.

Academic freedom is indispensable for research, a fact that has often been emphasised and is generally accepted. Occasionally, however, consideration for academic freedom is put forward as a reason for rejecting all outside influence on research. This sort of independence is far from the world of reality, and is caused by lack of understanding of what academic freedom is and should be, and a failure to appreciate that only some aspects of academic freedom can be regarded as absolutes. Academic freedom is not a privilege which has been granted to researchers as their birthright for ever and ever. It is rather one of the conditions that helps to ensure that research produces the best possible results, and that those who pay the researchers get their money's worth.

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The first element of academic freedom, freedom to draw the conclusions which the work of the researchers leads to, must be an unqualified and absolute demand on the researchers and on those who make decisions regarding research. Nothing good can come from ordering a researcher to achieve certain results, or from forbidding him/her to do so.

Research shall not lead to pre-defined results

It may be necessary for financial reasons to limit the second element of academic freedom: free choice of method. Apart from requiring the researcher's own time, nearly all research also calls for resources, for instance for computer equipment, apparatus, and technical assistance. Nobody can invoke academic freedom as a reason for having unlimited means at his or her disposal. There must, however, be no constraints on methodological freedom caused by tradition or rigid orthodoxy in the research community. Major breakthroughs are often achieved by researchers applying new methods to old problems. Limitations on choice of method can become a serious brake on the development of research.

The third element of the freedom of research, freedom to publish the results, is not absolute. Journals and publishers decide themselves what they wish to print. Publication costs money, and it cannot automatically be every researcher's right to get whatever he or she may like into print. There can only be freedom to seek publication within the framework offered by the world of research. Researchers in private enterprises can obviously not have the freedom to publish, and there may also be constraints on researchers employed in the public sectors.

The fourth element of academic freedom, freedom to choose tasks, is limited for virtually everybody.

Researchers are not completely free to choose their tasks

There is in fact an intervention here, when resources are made available as programme funds, or when the research councils choose priority areas and announce them publicly. Researchers are faced with a choice: they can get resources provided they choose assignments within predetermined areas, otherwise not.

Researchers are also committed by the collaborations they participate in. A researcher cannot suddenly back out of a project and let his or her colleagues down. Nor can individual researchers break out and publish on their own; they must agree with their colleagues on publication.

Researchers in universities traditionally enjoy considerable freedom to choose tasks, as long as they keep to the fields they are employed to deal with. In public research institutions other than universities, and in the private sector, there are naturally considerable limitations on the choice of tasks and of methods. On the other hand, research might easily come to a halt if researchers were only to get tasks from outside and were denied influence on how they are formulated, and if they never got a chance to formulate problems and tackle them in their own way.

Academic freedom is often linked with job security. Nobody should risk being dismissed for standing firm on the first element of academic freedom: freedom to draw the conclusions to which their research leads.

Otherwise researchers are subject to the same job security or insecurity as everybody else. But research is a long-term affair. It takes time to build up good research groups and research environments, and employers must be aware that research can be seriously affected if researchers are concerned about their continued employment, or if budgetary considerations cause sudden dismissals.

In the Anglo-Saxon world it is usual for university teachers to have "tenure", a special kind of job security. This means that they are employed in permanent positions and are secured against dismissal, provided they do their jobs properly. Tenure does not, however, entail unconditional job security: the necessary funding must be available in the universities' budgets. In Denmark, too, we have a sort of tenure, although legally it does not reach beyond the provisions of collective agreements, the Salaried Employees Act, the Public Servants Act, the Finance Act etc.

Freedom and responsibility

Freedom and responsibility belong together. Researchers who are paid out of public funds to do research, and who enjoy considerable freedom of research, have thereby accepted a commitment to do their best in their research.

In large and important areas the researchers know best, or are the only ones who know anything at all, giving them considerable power and possibilities of gaining influence. Researchers are responsible for ensuring that their knowledge is shared by society, and for managing their knowledge responsibly through openness.

Researchers have an obligation to choose methods and tasks that are in accordance with the laws of the land. This leads to limitations: for instance, on the use of laboratory animals; the involvement of humans in experiments; and publication of archive records.

Like everybody else, researchers are responsible for what they choose to do, and for knowing their own limitations; moreover, the development of research raises many difficult problems. Researchers are also responsible for reporting the problems raised by their research. Consequently a lot of effort is expended on ethical standards for research, and on the ethical problems raised by research.

Within health sector research, there is lively and meaningful debate on research ethics and on the limits to research. As a result, the health sector is the first sector to have developed a public system to deal with questions of ethics, the so-called committee system for scientific ethics.

The responsibility of researchers cannot, however, be translated into a simple set of rules telling them what to do and what not to do. Reality,

4. What is research?

including the reality of research, has many facets. In our everyday lives there are no clear-cut rules telling us exactly what to do in any given situation, and making us feel safe if we stick to them; similarly, researchers will rarely have rules that make them feel safe.

4.6. Management of research

There is a need for research management at all levels and this must be conducted so as to leave room for academic freedom. In addition, management must uphold the ability of research as such to find new ways while making certain that there is room for the unexpected and the critical.

Management of research must build on authority – not on formal rights

Like many other activities, research needs management. Research management is required at many levels: in individual groups of researchers; in institutes and research institutions; in research councils; in the central administration; and in private enterprises. Research management is best when it is based on academic authority, on insight into research, and on openness rather than on formal rights. Research management is required to make coherent decisions, to inspire, to initiate, to stop the inadequate, to build up, and also to ensure that those who foot the bill get research of quality and relevance in return.

An important aspect of research management is the appointment of new staff. Competent research directors are characterised, among other things, by their ability to attract and engage the right sort of staff and give them enough scope to develop their own potential.

At the same time, to a considerable extent research is able to break new ground on its own: innovation has been an important factor in the development of research. Research largely sets its own agenda, decides which subjects to deal with, what problems to tackle. All along, however, research has developed in step with the surrounding world.

It is necessary to have room both for research management and for self-management of research. Too much of either element can bring development to a halt, put a brake on the unexpected and the critical. All systems, including that of research itself, are to a high degree self-conserving and averse to change. It is necessary to create place for the new.

4.7. Research is international

Research is international and it is essential for Danish research to be an integral part of the international research system. Our en-

trance ticket to international research is that we have something to contribute. Quality is measured by an international standard.

Research is international, and the system by which research distinguishes what is good from what is bad is international too. If a country isolates itself, it cuts itself off from the necessary evaluation of quality.

In some disciplines in the humanities (for example Danish history and Danish language) and in the social sciences, but also in the natural sciences, (for instance botanic and zoological studies of Danish flora and fauna), the subjects are located in this country. Nevertheless, methods, scientific language, ways of thinking and working will be influenced by international research. No field can use references to research traditions or national importance to sustain claims to be above quality evaluation based on international standards.

All research must be judged by international standards

The international nature of research is clearly expressed in its extensive cooperation across national boundaries, cooperation comprising not only specific research projects, but also education, stays by visiting scholars, meetings, symposia, conferences, journals and so on.

National barriers to international scientific cooperation exist and these are harmful: nobody can gain from remaining outside of international cooperation. All countries that have tried to keep their research and their researchers isolated from the outside world have paid a high price. This price includes lack of knowledge of, and ability to, exploit the results of global research, lack of innovation, and lack of competition.

Internationalisation is more important today than ever before. The extent and pace of research is constantly increasing, the structure of the research system is changing rapidly, and so are the conditions for research. It is becoming more difficult for researchers to get anywhere unless they cooperate. Researchers only become involved in cooperation if they have something to contribute. It is a prime concern for researchers to create their own networks of personal relations all over the world. Today research is conducted in a European or global research market. Denmark must be able to make its contribution there, rather than being confined to merely picking up results. It is easy to become indifferent and neglected. Danish research must be as good as research elsewhere, and Denmark must have its place on the global research map. Although it may perhaps be necessary in Denmark to conduct research which is of no interest to the international scientific community, this should definitely not be used as justification for refusing to apply international standards. Moreover, it can only be true for a very limited part of Danish research.

4. What is research?

4.8. Research quality

It is necessary to insist on the concept of quality in research. The evaluation of quality cannot be an automatic or mechanical process, because it must be based on insight into the nature of research as well as on quality evaluation by research itself. International quality evaluation must not, however, obstruct breakthroughs in research.

Evaluation of the quality of research must include the relevance of the research, its use of theory and method, and its conclusions as seen in the light of the objectives set up and the materials used. Research of high international quality is distinguished with regard to subject, method, and theory.

Quality refers to subject, method, and theory.

In practice, quality evaluation by research itself is based on appraisals made by the best researchers. This is true of conferment of academic degrees, of appointments and promotions, of allocation of resources internally in research institutions and research councils, and of acceptance of papers by scientific journals and books. At best, this is a quality assurance system of great importance to research.

On the other hand, there are some notable drawbacks to this international system. In the research community, in individual countries as well as at the international level, conservative attitudes can be found in the different fields which can lead to obstruction of new ways of tackling the problems. At worst, the influence of experienced researchers can curb the development of research, not least of new, pioneering work.

4.9. The researchers

If research is to be of the quality required by society, there is need for a proactive effort in the education of researchers as well as for good working conditions for researchers. Consequently the research system must be transparent, effective and stable, and researchers themselves must be able to influence their own tasks and working conditions. On the other hand, researchers must show understanding for wishes and demands from outside, and be able and willing to adapt to change.

The researchers themselves are the most important

The most important element in the research system is the researchers themselves. Hence it is necessary to know something about the researchers, how they are recruited, and under which conditions they thrive and produce good results.

Good researchers are always deeply interested in their work, and research cannot be conducted without strong commitment. Obviously talent is required as well. But commitment and talent alone are not enough. New researchers must be educated within the world of research, and educated by researchers. The updating and future of research is dependent on a constant intake of new, young researchers.

That is why the training and recruitment of researchers is important for research management and research policy.

Researchers can only provide good research if their working conditions are good. These include adequate resources as well as possibilities for and encouragement to participate in national and international cooperation. Clear tasks are necessary, and researchers must have influence on the formulation of these tasks. Above all, researchers at universities must be able to chose their own tasks. The researchers must work in transparent, effective and stable systems.

At the same time researchers and the world of research must be able to adjust, like all other parts of society. This makes demands on researchers, but also increases their need for support. The researchers themselves must appreciate the need for adjustment.

At the risk of over-simplifying it might be said that nurturing personnel is necessary in the research system, just like in any other system.

4.10. Research and education

Good education is dependent on teachers who are able to update their knowledge and acquire new knowledge. One of the ways in which teachers can do this is by being active in quality research. In fact research has something to offer all parts of the educational system. It is not enough to ensure the link between research and university curricula. Nor is it necessary or even realistically possible to ensure that all teaching in universities is provided by teachers who are also active researchers.

It has always been the responsibility of universities to conduct research and to teach, and most university teachers are also researchers. It is often emphasised that research and university teaching belong together, and this coupling has had a decisive influence on the structure of universities as we know them today.

It is not, however, enough to say that we have a university education, and that research is part of it. This connection does not arise by itself, but there must be actual or potential, relevant research in the area. It is necessary to argue for the relevance of research in individual areas, and for the relevance of research to education.

The coupling between research and education is justified by the argument that university curricula must be kept up-to-date, that it is necessary to teach current knowledge, and that there must be a constant addition of new knowledge and scrapping of old. Graduates must be aware of the need to produce new knowledge and be able to renew their own fund of knowledge.

It is, however, a false simplification to maintain that all further education must be provided by researchers, and conversely that all other kinds of education do not need any connection with research.

Any kind of education can decay and go out of date. This process can only be averted by having teachers who are able to keep alive, to keep up to date, to keep abreast of developments, and to acquire new knowledge. This applies equally to primary and secondary school teachers and to teachers in universities.

Thus the research system has something to offer that is relevant to all education, and the research system has failed in its duty if it confines itself to ensuring the link to university education. The research system and researchers must work towards ensuring that their new knowledge becomes important to the entire educational system. Similarly, at all levels of the educational system an active effort must be made to obtain knowledge and renewal from research.

Not all university researchers are good teachers, or take the time to become good teachers. Not all university researchers produce good research: while good research gives life to teaching, bad research can do harm. Not all university teachers are good researchers. University teachers may be good teachers without doing any research themselves; and in fact a considerable part of Danish university teaching is given today by teachers who are not researchers. What is decisive is to have university teachers who live in a responsible and active research environment within a tradition of research which demands and ensures that they follow the development of research. Proposals for relevant educational initiatives can and must come from many sides, but the academic level must be guaranteed by the active researchers. Only in that way can we secure the research dimension of the continual renewal of individual educational modules as well as of the entire curriculum.

5 The national research strategy – a survey

5.1. Definition of a national Danish research strategy

A national research strategy is a binding framework for making decisions on research.

The national research strategy must include:

A strategy is a binding framework for decisions

Overall objectives of Danish research (Chapter 3)

Establishment of society's needs and demands for research results (Chapter 6), opportunities of research and what it can offer (Chapter 7), and the international challenges Denmark is facing in the field of research (Chapter 8).

Opportunities for and demands on all major decision-makers or actors in the world of research, including ministries, research councils, and public research institutions (Chapter 9), as well as private companies engaged in research and development activities (Chapter 10).

Determination of objectives and priorities for Danish research, together with indications of how these objectives can be attained.

Determination of the relationship between strategy and decision-making in the research system, the research administration, and research policy (Chapter 11).

Demands for framework and structures in the research system based on a view of the nature of research and its role in society (Chapter 4 and 11).

A proposal for how regular adjustment of the strategy can be made.

Limited funds must be spent in the best possible way

The purpose of the national research strategy is to ensure that Danish society reaps the necessary benefits from research, and that the limited funds are spent optimally. This purpose can only be realised by a common strategy. A unified framework is required, if a sensible whole is to emerge from a system with many decision-makers and many different research activities. The strategy must define this framework as a guideline for the decision-makers involved.

In view of the preceding, the Government has decided that a national research strategy is to be formulated. The proposal was put forward by

the OECD-panel which in November 1994 presented the results of their evaluation of Danish research policy and the Danish research system. Although the OECD-panel included only technical and natural sciences in its considerations, it was unanimously agreed that the national strategy must comprise the entire area of research, among other things because there are strong interfaces and comprehensive collaboration between the humanities and the social sciences on the one hand and the technical and natural sciences on the other, and also because it is important to promote interdisciplinary cooperation.

The strategy is to comprise all Danish research

During the past fifteen years there have been several tentative attempts to formulate a national strategy, including a series of White Papers on research policy, Planredegørelsen for Forskningen ('Report on Research Planning') 1983, and "Dansk Forskning 1987 – 2000" ('Danish Research 1987 – 2000') 1986 (both publications are from the Planning Council for Research, predecessor of the Research Policy Council). In sub-areas and in a number of research institutions a great deal of effort has been devoted to the formulation of research strategies. Reference can be made to the strategic plans of the research councils from 1987/88 and 1991, a proposed strategy for agricultural research from 1994 adopted by the Government in January 1995, and a proposal for a health research strategy (the NASTRA report) from 1995. The proposals have, however, either been confined to limited areas, or they have been enquiries, analyses and proposals rather than binding frameworks.

In the research system there is the same need as anywhere else for an ability to adjust swiftly to changed circumstances, to shoulder new responsibilities, and to move resources. On the other hand, it takes many years to build up new areas of research and new research facilities, and decisions on inter alia large investments, particularly in buildings, reach far into the future. The strategy must apply to the next decades, but it must come into operation immediately and be adjusted regularly.

It is essential that the strategy become binding on decision-makers in the Danish research system. Should the strategy be perceived merely as a list of some appealing, but unclear or unattainable objectives, it is unlikely to bring us any further ahead than earlier reports and proposals.

The strategy covers the entire Danish research system, including private sector research. One of the overall objectives of the national research strategy is that research must benefit industry and production. Chapter 10 contains a discussion of the place of private research in the national strategy.

A strategy contains more than priorities

It is a commonly held belief that the national research strategy should above all be concerned with setting research priorities, that is with the subjects of research. This is naturally an import aspect of the strategy.

Objectives must be determined in the light of an overall consideration of wishes and needs, prospects and opportunities, and international challenges. Hence the strategy must determine what Danish research is to focus on, and where the country's researchers should carry out a national specialisation. Without such priorities, we in Denmark will be losing too much in quality, international reputation, and competitiveness.

Research does not lend itself to command management

But not everything can and shall be decided from above. Research does not lend itself to command management. Decisions should be made against the background of an open debate, and they must be made at many levels.

It is also necessary within the strategy to deal with ways in which the academic objectives can be attained. The implementation of priorities requires the availability of a suitable system.

Consequently the strategy must include academic objectives as well as a framework for research.

5.2. National strategy and research policy

Research policy is necessary because research is necessary, and because public resources are being spent on research.

Research policy is the responsibility of the Folketing (parliament) and Government, although it is a responsibility that must be carried out in cooperation with the research administration, the scientific community, and the users of research.

Folketing and Government decide on the general structure and priorities of research as well as on appropriations for research.

Folketing and Government decide on the authority to make decisions within the research system, and are responsible for ensuring its operation as a well-functioning whole.

The establishment of a national research strategy is an important aspect of research policy. In return research strategy should provide a guideline for research policy.

Research is important for Denmark, and hence it becomes an important political obligation to ensure that Danish society is provided with the research it requires, that the necessary resources are allocated, and that they are employed in the best possible way. Research policy is not

5. The national research strategy – a survey

an evil, not even a necessary evil. Research policy is an integral part of the country's political system. Part of the strategy consists of establishing the obligations of research policy.

There is considerable self-administration in research, and that must be retained. The delimitation of self-administration must, however, be made through research policy, and self-administration cannot replace research policy. Researchers in the public sector receive grants from the public purse and will obviously, like everybody else, be subject to the conditions laid down by the legislature. Research cannot be a state within the state.

Research cannot be a state within the state

Research policy is the responsibility of Folketing and Government. It is only possible, however, to implement a sensible research policy if it is founded on advice and suggestions from the central administration, research councils and similar bodies, research institutions, researchers, users of research, and others with an interest in research matters.

Folketing and Government establish the overall framework for research, including the structure of the research system, the superior advisory system, the authority to make decisions in the system, and the budget appropriations which together make up the public research budget.

Folketing and Government are obliged to determine the overall priorities and the connection between these priorities and the budgets and programme grants of the research institutions.

The research policy must ensure the smooth running of the interplay between all parts of the research system, even though the research institutions, the research councils and others have been granted considerable powers to make decisions. The research system must be a whole based on coherence rather than on uniformity.

Strategy is both an objective and a means of research policy

It is an important responsibility of research policy to establish a national research strategy as defined in Chapter 5.1 (page 28).

On the other hand strategy must be an important tool of the research policy.

5.3. How is the national research strategy to be established?

The national research strategy must be formulated with the assistance of the entire research system. Only then can it be expected to win wholehearted support. It must not become a pointless compromise, where all views have been incorporated, or where all controversial views have been eradicated. It must be clear and unambiguous, and acceptable to the scientific community and the surrounding society.

The national research strategy will have far-reaching effects on the entire research system. Although it is not meant to become a straitjacket, it will interfere with the rights of individual decision-makers.

The entire research system must become involved in the formulation of the national strategy

It is therefore necessary that the entire research system should become involved in the formulation of the national strategy, understand its process of formation and why the strategy turns out as it actually does. The national strategy must not become a compromise with everybody agreeing on everything; that would make it devoid of substance. It must be created through an open and transparent process, and it must end up being very clear. Otherwise it will not be possible to implement it.

The strategy must be based on an awareness of needs

The strategy must be based on awareness of needs for research, including the needs of industry, cf. Chapter 6, as well as knowledge about the potentials of research and the suggestions and wishes of the research community, cf. Chapter 7. Hence it is necessary to ask for contributions to the strategy from users of research as well as from the research community.

It is essential to build on knowledge about the development of international research, as well as about the opportunities and challenges Danish research will be facing in international research collaboration, cf. Chapter 8.

It is essential to build on proper analyses, including future studies like, for example, the British "foresight" analyses.

It is also essential to include knowledge about research administration and the structure of the research system.

All these contributions must be seen in context, and as far as possible be coordinated into a whole. This work must take place in the Ministry of Research and Information Technology with involvement of other ministries. The Research Policy Council or its successor will be playing a major role in formulating the national strategy.

Following a public hearing, the final proposal for the national strategy will be adopted by the Government and finally published.

Chapter 12 contains a proposal setting out how the activities can be planned so that the national research strategy can be finalised by the middle of 1996.

5.4. How can it be ensured that the strategy will actually be used and that it will work?

Strategy for the future

In order to ensure that decisions within the framework of the national strategy can take effect as soon as possible, the strategy must be implemented immediately after being adopted. Some decisions will have short-term effects, whereas others will stretch several years into the future. The strategy must be reviewed regularly on the basis of the knowledge accumulated by consistent follow-up.

The national strategy must be followed up. Consequently it must be indicated how the objectives can be attained, and who is responsible. It must also be shown how the results of follow-ups can be used in making decisions.

Follow-up and responsibility

The demands for follow-up and application of the results must be made available to all decision-makers within the research system.

Danish research must be monitored regularly to ensure that its quality is of international standard. It must be the responsibility of the director or the management of individual research institutions to take action, if this is no longer the case.

In order to ensure that the national strategy does not merely become a non-binding objective, it is necessary to be able to ascertain whether it is being followed. This means that at every step of the strategy a decision is necessary on how to establish whether the objectives are being attained.

For example, when the national strategy sets up international quality as an absolute requirement, it is necessary at the same time to check whether this demand is being met. It must be made clear who is responsible for the follow-up, and in what way the follow-up activities will be used when making decisions in the future.

Responsibility and right of disposal over appropriations are closely linked. Consequently the demands for follow-up must to a large extent be addressed to whoever is accountable for appropriations, cf. Chapter 9. There are, however, also overall responsibilities concerning follow-up and monitoring of quality. The national strategy must indicate where this responsibility should be placed.

Society's needs and requirements for the results of research

6.1. How can we produce an overview that can and will be used?

Danish society needs research and the results of research. To be able to set up a national research strategy, it is necessary to analyse and describe what society actually needs.

There are four reasons why this is a difficult task:

Firstly, there are many who can and should be able to influence the determination of needs, cf. Chapter 6.2 (page 35). How can they all become involved without creating a chaotic message?

Secondly, research consists of many – and many different – things. How can this multiplicity be described in a comprehensible manner?

Thirdly, it is a question of looking ahead. It is tomorrow's problems rather than yesterday's that have to be dealt with. How can we ensure that we are not merely concentrating our efforts where they have previously proved useful? There are enough conservative influences at play within the research system itself as well as among those who are raising demands for research.

Not all society's problems can be solved by research

Fourthly, contemporary society is subject to many problems which research can help to solve. But not all of society's problems can or should be solved through research. Some problems do not lend themselves to any solution at all, and other problems can only be solved by political means. It is important that research in a problematic area should not be used to avoid or postpone necessary decisions elsewhere in society.

If it merely becomes a long list, the description of society's needs and requirements cannot lead to anything useful. Needs for research can be expressed in a few technical terms, and it is easy to point out problems which ought to be solved. But although it may be easy to enumerate problems, it is far from certain that they can be solved by research.

It is necessary to be more specific about demands for research. What precisely is to be achieved in a given area? What size of effort is required? How quickly will the work have to be done? What is the character of the effort required?

Many expressed wishes are wishes for knowledge as much as for research. Out of ignorance, things may be requested which have already been done. They may also be requests for repetition of something that has already been done, because the first outcome was found unsatisfactory.

Danish research represents less than 1% of total global research. What is often desired is access to the 99%. In such cases, an independent Danish research effort is necessary mainly as an entry ticket to the 99%.

A systematic effort, not just a long shopping list

It is a difficult task which can only be solved by a systematic effort. Although systems may lead to arbitrary delimitation, there is no other way. A long unstructured list is not a viable alternative.

The traditional grouping of research into disciplines cannot be used to systematise society's needs for research. This is because the needs often cut across the partitions, and not least because society has problems, whereas research has disciplines.

In Chapter 7 the presentation is based on a traditional grouping by disciplines corresponding to the OECD grouping by areas of research and disciplines, whereas in this Chapter we propose to use the OECD grouping of research by objectives. The problem of grouping and delimitation by objective or discipline corresponds to the problems involved in deciding whether a research council should be discipline or sector oriented.

At the end of this Chapter we shall give four examples of the kinds of societal need in various areas that research will be called on to meet. The examples differ a great deal in form and content. In this way they illustrate the complexity of describing society's needs for research, and make it clear that this cannot be done by following a common prescription.

6.2. Who is to contribute

Society's needs for research must be determined with due regard for contributions from all parts of society. Everybody with views and wishes must be able to express them. This applies to politicians, ordinary citizens, the administration, organisations, associations, institutions, private enterprises, and the scientific community itself. This does not, however, mean that the demands and requests included in the national research strategy will comprise all suggestions. Including all contributions would make the conclusion vague and noncommittal.

Many wishes and demands can best, or perhaps only, be formulated in a dialogue with the researchers themselves. The research system must contain facilities for this dialogue.

The various contributors to the formulation of wishes and demands must be fitted in at different levels in the research system. Not everybody will be invited to contribute to formulating the overall national strategy; more will be involved in the local strategies of individual decision-makers, and as part of their daily work very many will become involved in direct negotiation with research institutions, research councils, and researchers.

Chapter 12 contains specific proposals for the involvement of many potential contributors in the formulation of the national research strategy.

In many countries future studies or "foresight" analyses are carried out in order to describe the opportunities and challenges of the future, and to serve as basis for establishing objectives for the research community.

The latest and most comprehensive of these is the British foresight project which was concluded in May with the publication of 16 reports.

We cannot make a living by deliberating

We must learn what we can from abroad and we may be forced to carry out a similar project. But we cannot live merely by deliberating about things and writing about them. It is most important that we keep looking ahead, not back, and that we do not confine ourselves to thinking thoughts, but also see to it that they are actually utilised.

6.3. A proposed framework for a description of society's need for research

We shall not be able to get any further without systematisation, – with all its concomitant drawbacks. We shall here propose a new grouping of the area based on the classification by purpose which is used in reporting to the OECD as well as in research statistics. We have changed the OECD grouping in a number of places in order to achieve a more adequate description of Danish research. The proposed grouping is, however, so compatible with the OECD grouping that the statistical information to a considerable degree can be used for an evaluation of the Danish efforts for various purposes.

No conclusions can or should be drawn from the relative fullness of description in individual areas. This is partly because some things are easier to describe in detail than others, and partly because a detailed description is more important in certain cases.

1. Identity, history, culture

The need for research in this area originates from wide circles and is primarily addressed to the humanities and the social sciences. There is a demand for knowledge about local identity and roots tied to language and value systems, as well as about the role of this knowledge in

international affairs and conflicts. Cultural changes within and across cultural boundaries increase the need for knowledge, not only about the specific character of cultures, but also about the factors and processes which cause or restrain changes, as well as about their historical prerequisites in patterns of behaviour, practices, and forms of consciousness. There is a need for basic research in fundamental cultural processes, and strategic research in areas of special cultural development, such as, for instance, the relation to the natural basis, cross-cultural communication, and extended knowledge about the many cultures with which increasing globalisation of politics, trade and production is bringing us into contact.

2. Environment, natural sciences

Wishes here are mostly addressed to the natural sciences. Research in this area comprises structures and processes in phenomena outside or only indirectly subject to human influence: the structure and development of the universe, nuclear processes, the history of the earth, climatic and atmospheric conditions, the development and character of biological species, and the interaction between living and dead nature.

3. Economics, employment, society

It is obviously the social sciences we are dealing with here. There is a general need for knowing what is going on in our society, and how it works. Wishes and requests emanate from wide circles, as well as demands from, among others, a number of ministries: the Ministries of Labour, Finance, Taxation, Social Affairs, and Economic Affairs. The entire health sector also needs knowledge about the development of society. There is need for research and knowledge relating to economics, labour market conditions including working environment and working conditions, and in the field of demography. The public and private service sectors, and the private sector in general are interested in knowledge and research results.

4. Culture, mass media and leisure

The relationship between work and leisure, voluntary as well as enforced, in the modern consumer society affects the need for material production, for the use of landscape and natural resources, for social services, for transport, for media, and for the communication of knowledge. Changed patterns of behaviour, upheaval in social patterns of organisation, and new demands for planning all call for research. The entertainment industry is one example of an economic, material and cultural driving force in a development that will leave its mark on a long series of public and private sectors. Another case in point is mass tourism and its impact on changes in productive and recreative uses of land as illustrated by mixed forestry.

5. International developments

Needs and demands in this sphere are motivated by consideration of the country's foreign policy, foreign trade and development aid activities. There is also a need for knowledge and research caused by the voluntary and involuntary internationalisation in which the country participates. The need is addressed mainly to the humanities and the social sciences, but also to health and disease research, technological and scientific research, natural science and the like. Nearly all of the research system is able to contribute, since research is an important engine of progress, and because the researchers have special and unique knowledge about what is going on, and what may be expected to happen in the future.

6. Health and disease

There is a demand for knowledge on and research in the causes of disease, prophylaxis, care, and therapy. The needs range widely: lifestyle, working environment, and environmental factors must be included. Both the private and the public sectors are vitally interested in this area.

"Proposal for a national strategy for health science research" (The NASTRA report) from January 1995 contains a description of research in the health sciences as well as a proposed strategy.

Wishes and demands are aimed at research within the health sciences, including clinical research and research in public health, and at biology. It is perhaps appropriate to emphasise research in epidemiology, prophylaxis, surgical intervention, and also nutrition and toxicology. In relation to the needs of industry, the demand is concerned with, among other things, biomedical research.

For further details see Chapter 6.5 (page 44).

7. The external environment

The importance of this area lies in the demand for sustainable development and justifiable utilisation of the natural resources for which we ourselves are responsible, as well as in the wish to highlight Danish products and services from an environmental point of view. The demand is directed at biology, (particularly ecology and toxicology), the geosciences, (in particular climatology, geology, geophysics, and geochemistry), the technical sciences, (in particular biotechnology and material flows), and the social sciences, (behaviour, patterns of consumption, and environmental economy). There is a special need for problem-solving research, (including research on the use of land and ground-water resources, and on new technologies), as well as for systems analysis, (including methods of monitoring, telemetry, and modelling).

8. Agriculture

The demand for research in this area stems from international and market developments, the ever growing societal and political focus on sustainability, environmental and production ethics in agriculture and food production. In addition there is a political commitment to underpin and reinforce the viability and competitiveness of this branch of industry. On the basis of this, in January 1995 the Government adopted a strategy for Danish agricultural research. It will obviously be necessary to take this strategy into account when formulating the national strategy. The strategy for agricultural research describes challenges, wishes and demands, and indicates how these can be met. It goes without saying that agricultural research comprises both plant and animal production.

See also Chapter 6.4 (page 42).

9. Food products

There may be good reasons for treating research in food products separately, as this is an area attracting considerable interest from consumers, agriculture and industry. Demands are addressed to technical disciplines as well as to fundamental disciplines in biology and chemistry. There are needs for nutritional research and social research. The strategy for agricultural research also includes research in food products.

10. Materials

Demands and requirements in the area of materials is a consequence of enormous developments over the last 25 years. The progress in information technology is based on the development of new semiconductor components, but materials development is also of key importance in less high-technological industries. The competitiveness of many Danish companies will depend to a large degree on their ability to exploit the possibilities which new and improved construction materials and materials for sensors are constantly making available. An example of a decisive breakthrough is the development of composite materials with higher tensile strength and reduced density. Internationally, materials R & D has been upgraded, and in Denmark too the subject enjoys high priority through the Materials Technology Development Programme (MUP). The demands are addressed to technical disciplines and basic disciplines in the natural sciences, primarily physics and chemistry.

11. Information technology and electronics

Here demands and requirements come from large segments of the public sector, including the service sector, as well as from the private sector. As information technology and the use of electronics play an

important role in the development of society, requests and opinions are also expressed by broad segments of the community. Demands are aimed at research within the area itself and at basic disciplines such as mathematics, computer science and physics. These demands are also aimed at social research and the humanities.

A more detailed account with special emphasis on information technology is given in Chapter 6.6 (page 47).

12. Communication and media

This area is closely related to information technology. Here again there are requirements and demands from both the public and private sectors and from the general public. The requirements are addressed to the public and private sectors from production units and from information and dissemination institutions. Demands are aimed at research within the area itself, the humanities, social research and technical research, and also for research in, for example, cognition and space research (satellite communication). Problems will have to be solved within each discipline and relations between them established: social and mental changes, communication of knowledge and technological development, economics and access to knowledge.

13. Transport

Transport is a significant element of the contents of and background to modern society, and it causes great environmental problems. Demands involve information technology and other technical areas as well as social research.

14. Energy

This is an important area owing to society's dependence on energy, because energy consumption represents a significant part of the national economy, and because the production and use of energy cause great environmental and resource problems. Demands are directed at a number of natural science and technological disciplines including physics, chemistry and geology, as well as at the social sciences. Research is required on specifically Danish problems: supplies, structure of consumption, limitation of emissions, energy savings, energy storage, improved exploitation of known oil deposits, biofuels, and renewable energy.

15. Production technology and construction

This area is primarily of interest to the private sector. The wealth of Danish society in future will also depend to a large extent on the existence of manufacturing enterprises that are competitive at the global level. The objective of research in this area is to ensure the continued competitiveness of Danish industry as a whole: the highly R & D in-

tensive as well as other industries, and large as well as smaller enterprises. The continual improvement of their product development and production technology are important prerequisites for the success of industrial enterprises. It has been demonstrated that the main barriers to industrial competitiveness can be found in the traditional engineering disciplines as well as in the "softer" organisational spheres. Research in how companies realise and overcome the barriers to competitiveness, and how they manage rapid change, are therefore among society's most important objects of research. Demands are made of a number of technical disciplines, including information technology and electronics, as well as of basic natural science disciplines such as physics, chemistry, biology, and mathematics. There is also a need for research in methods of production which take into account environmental and health problems.

16. Education

The educational system has requests and demands on the research system. It is necessary to adopt another angle of approach than in the other 15 areas, but it is essential to include the needs of the educational system in the activities with regard to didactics, pedagogy and the psychology of learning, as well as to the general delimitation of the academic area.

Chapter 6.7 (page 49) contains a detailed account of the area.

The grouping does not include everything, and some things do not fit into any one category. This is inevitable, and no doubt the analysis can be improved. Any improvements should not, however, consist of increasing the list from 16 to 100 items, as it would then no longer be a useful tool. Our aim has been to make a proposal as to how to structure the debate concerning society's need for research. In order for the list to be simpler and more relevant to Danish conditions, a few OECD categories have been excluded from our list, while other OECD categories have been distributed among several categories, and a few new areas have been added.

The main deviations from the OECD classification are as follows.

"Economics, labour, society" (3) comprises four categories in the OECD classification: "Living conditions and physical planning", "Social conditions", "Working conditions", and "Economic planning and public administration".

The OECD category "Transport and telecommunications" has been divided between "Communication and media" (12) and "Transport" (13).

The media are included under "Culture, mass media and leisure" (4) in accordance with the OECD classification, but are also treated under "Communication and media" (12).

The OECD category "General advancement of science" is treated under "Identity, history and culture" (1) and "Environment, natural history" (2)

The OECD category "Mining, trade and industry" is dealt with under "Materials" (10), "Information technology and electronics" (11), and "Production technology and construction" (!5).

The OECD category "Exploration and exploitation of the earth and atmosphere" has been omitted as a separate category, but is treated under "Environment, natural history" (2), "The external environment" (7) and "Energy" (14).

The OECD categories "Space Research" and "Defence" have been omitted.

6.4 Agriculture. Example 1

The following is an example of a strategy for a single area. The reason for the inclusion of this example in the present White Paper, is that the report entitled "Proposal for a national strategy for agricultural research" from June 1994 was adopted by the Government in January 1995. Thereby the country received a general national strategy for agricultural research.

The starting point for the committee which formulated the "Proposal" was as follows:

The anticipated development and needs of agriculture in the light of the development of society, the changes in the EU's agricultural policy, and the consequences of the recently concluded GATT agreement. Other important considerations are the constantly growing public and political focus on sustainability, environment and production ethics in agricultural and food production. The increasing complexity of scientific problems and the concomitant increase in the demands for more high-technological research facilities and more sophisticated, expensive equipment have also been important parameters of the deliberations.

On this basis the following objectives and criteria for priorities have been laid down:

To strengthen prophylactic efforts with regard to the health of domestic animals, including increased correlation between production, health management, and animal welfare.

To reduce the amount of resources spent in agriculture with a view to reducing costs as well as environmental impact.

To improve the quality of raw materials and create a basis for the development of differentiated products in accordance with the requirements of the processing industries and the consumers.

6. Society's needs and requirements for the results of research

To enhance the knowledge basis for appropriate extensivation, set-aside, and land management.

To increase the knowledge basis for sustainable development in rural districts.

The committee also proposes a number of up and downgradings of priorities and indicates how the strategy can be implemented.

On the basis of the committee's recommendations and following broadly-based consultation, the Government has adopted the following:

That in publicly funded agricultural research more emphasis is to be laid on basic research.

That interdisciplinary national and international research cooperation shall be extended and given higher priority, among other things by increased mobility of researchers between institutions of higher education and Government research institutes, between national and international research environments, and by ensuring financial means for research cooperation.

That efforts shall be made to ensure that the relation between basic, contract research and programme appropriations over the next five years reach a 60%, 20%, 20% distribution, with due regard for institutional distinctions.

That it shall be attempted by stages to move towards an increasing degree of user financing of application-oriented research.

That the committee's proposed revision of priorities concerning plant production as well as domestic animals and veterinary practice shall be effected.

That the committee's proposed change of priority from plant production to domestic animals and veterinary practice shall be effected.

That in the course of the next decade – taking into consideration the state of appropriations – a reallocation of research efforts as proposed by the Strategy Committee shall be carried out, including prioritising *the quality and safety of agricultural products, health and welfare research in livestock husbandry, and landscaping.*

That the strategy shall be adjusted and adapted within 5 years in the light of societal developments.

That an institutional and academic concentration of agricultural research shall be carried out, and that the changes in organisation shall be carried out in close cooperation with the parties concerned.

That any possible centre constructions shall be established with unambiguous management structures and independent appropriations.

That on the basis of the existing cooperation agreement, a formal collaboration structure shall be established between Risø National

Laboratory and the Royal Veterinary and Agricultural University concerning research in plant production.

That a Department of Health and Welfare of Domestic Animals shall be established at the National Institute of Animal Science.

That a Centre for Production and Health Management shall be established by the National Institute of Animal Science, the Royal Veterinary and Agricultural University, the National Veterinary Serum Institute, and the State Veterinary Institute for Virus Research.

That a clearer division of labour and better coordination shall be established in landscape research.

That an academic concentration shall be effected of research in the economics of agriculture and fishery at the Royal Veterinary and Agricultural University and the Institute of Agricultural Economics. The concentration to include joint localisation of activities.

That an implementation follow-up group shall be set up under the chairmanship of the Ministry of Research and Information Technology with representatives of the Ministry of Education, the Ministry of Environment and Energy and the Ministry of Agriculture and Fisheries, with a view to ensuring coordination of the above proposals and their implementation.

The above represents a concrete example of the evolution of a strategy within national strategy work. It will obviously be necessary to adjust and review the strategy for agricultural research in the years to come as a consequence of other work on strategy, and as a consequence of developments in this and adjacent areas of research.

6.5 Health and disease. Example 2

While the strategy for agricultural research described above has been adopted, the "Proposal for a national strategy for health research" (the NASTRA report), as its title implies, has not yet been considered by the Government. The Ministry of Research and Information Technology published the report in the beginning of 1995, and the public hearing has only just been concluded.

The NASTRA report proposes a national strategy for Danish health research, with the following characteristics:

Human resources must be ensured by deliberately concentrating on recruitment and training of researchers and provision of positions for researchers.

Only high-quality research should be conducted. Both existing and future research environments – within as well as outside areas with special priority – are to compete openly for funding by public and private sources.

This competitive system is not in conflict with the view that a limited number of priority areas must be selected, which should be particularly favoured by the supply of funds, under constant consideration of quality.

Criteria will be established for prioritising research.

The official report operates with the following criteria:

The prospect that the types of disease which in Denmark represent a dominant present or future burden for the individual or for society, will benefit materially by the priority area with respect to prophylaxis, diagnostics, treatment or care.

The existence, or possible development of Danish research environments, which have or may achieve a special position in relation to the international research community.

The likelihood of future breakthroughs in research.

The prospects of financial support for the area in general.

The viability of research in the priority area based on a general evaluation of the human, structural, and financial resources.

The likelihood that increased research in the area in Denmark will lead to lasting results.

The report points out the following specific priority areas:

genetic research
clinical intervention research
neuroresearch
prophylaxis research

Implementation of the strategy shall be ensured by means of a simplified structure of appropriations and allocation of the necessary financial resources.

The research shall be evaluated to provide a basis for any necessary adjustments of the strategy.

Communication of research results shall be an integral part of the research effort.

The NASTRA report is based on a recommendation in the OECD evaluation of Danish research to the effect that research expenditure should be increased from the present 1.7% of GDP to 2% by the year 2000. Against this background and in expectation of unchanged economic growth in Danish society, the authors of the report come to the conclusion that research in the health sector shall be increased yearly by DKK 150-200m. Hence the report contains priorities for this amount. It does not, however, exclude or accord lower priority to any existing health research.

Giving priority to prophylaxis research won general approval in the hearing phase of the report. The subject is described in more detail below.

Prophylaxis research

Prophylaxis research will be a priority area in a national research strategy with, inter alia, the following objective:

Research shall contribute to maintaining and developing a high level for all sections of the population with regard to health, culture, welfare, and protection of natural resources.

There is no overall strategy for Danish research in prophylaxis. Partial contributions can be found in the NASTRA report on health science, the strategy plans of the research councils, the strategic environmental research programme, and "Arbejdsmiljøforskning mod år 2005" ('Working environment research toward the year 2000').

Three groups of subjects are central in enlarged prophylaxis research:

A healthy life is a good life
Prevention of disease and of specific problems
Suitable methods of prophylaxis

A healthy life is a good life

"Keeping healthy people healthy" is an important task. The basis of knowledge required to solve this health-promoting task is still inadequate.

Research in "positive health" is achieving ever higher priority internationally. Positive health as a concept covers more than just an understanding of the causes of disease. It is also a question of a good life, environmental and personal prerequisites for a good life, and strategies for developing and maintaining the good life. There is a need for this kind of research, not least with regard to children.

The good life is also in focus in social welfare research, in research on environment and working environment, and in cultural research. It has become the focus of a sort of interdisciplinary convergence of research with rising priorities in international research strategies.

Prevention of disease and of specific problems

There is still a considerable need for research aimed at preventing disease and other specific problems.

The areas in question are:

Aetiology of diseases (including genetic conditions, lifestyle, living conditions)

Causes of social problems (including social inheritance and family conditions, material living conditions, personality structure, legislation)

Problems relating to the working environment (physical, chemical, biological and psychological aspects)

Environmental problems (air, water, earth, the immediate environment, traffic)

A high-priority research effort may contribute to avoiding diseases and maintaining the welfare society on a sustainable basis. In addition, industry has a material interest in environmental research and research on the working environment, as well as in the biomedical aspect of prophylaxis research. The Danish product register provides unique opportunities for organising chemical clean-ups and health-positive product development. The reports and proposals for strategies mentioned above may form a basis for general prioritising in this area.

Suitable methods of prophylaxis

The methodological basis for effective prophylaxis must be in order. This requires systematic research and evaluation efforts.

The effects of methods designed to change the population's health behaviour are still being debated. This also applies to individual strategies for developing and maintaining a good life.

The methodological basis for environmental monitoring and intervention can be considerably improved.

On the international level, considerable research resources are devoted to the study of methodology and prophylaxis in a broader sense. In several areas Denmark is well placed to participate in this development, particularly regarding register-based research, epidemiology, and toxicology.

6.6. Information technology and electronics. Example 3

This field has developed extremely rapidly in recent years, with regard both to technological possibilities and to the relation between capacity and price, resulting in the ever wider distribution of information technology products. As examples of this can be mentioned the number of people all over the world who use computers for work, learning, communication, or entertainment; the significant IT content in a large number of industrial products; economical and often environmentally friendly possibilities of replacing physical experiments with calculations and large-scale simulations; new dimensions in the prospects of public services and administration, international activities etc. etc.

This development has created a need for R & D from various sectors of society. During the past decade there has in fact been considerable research activity in both the private and the public sectors in relation to information technology and electronics. It may be appropriate to mention "Det teknologiske udviklingsprogram" (TUP) ('The technological development programme') from 1983, which had as its main objective the introduction of modern information technology in Danish enterprises; a number of large EU research programmes; the strategic research programme "Professionel Informatik i Forskning og Teknologi" (PIFT) ('Research programme on informatics') from 1991; the Microelectronics Centre established in 1990 at the Technical University of Denmark, and the proposal of June 1995 for a corresponding information technology centre.

Among the demands of business must be mentioned the need for graduates from the educational system, the demand for access to the international research network, as well as for concrete research results, cf. Chapter 10 (page 78). Due to ongoing internationalisation there is an increasing demand for a highly-qualified workforce, particularly in software which constitutes a constantly growing part of production and products. It is essential that the standard of Danish education should be equal to – or preferably higher than – the level in the countries with which we compete. This situation makes large (indirect) demands on research.

Industry needs to have the competitive advantage of knowing the state of the art in the various branches of information technology. The purpose is to be at least as far advanced as competitors with regard to new techniques and products and the like. In this connection, internationally oriented and active research environments with mutually binding collaborative relations with industry are a considerable asset. Participation in networks with access to up-to-date and interesting knowledge makes considerable demands on Danish research.

The business sector needs concrete results from research with present or potential relevance to companies. The requirements stem mainly from product development and may concern either the product's content of information technology and/or the technology of the design or production phases. Naturally, concrete demands change with time – at present the following are relevant (cf. the proposal for establishing an information technology centre):

Methods of product analysis and implementation of software projects

Quantifiable quality measures for software

Software interfaces with hardware as well as with users

Techniques of programming, analysis, and structuring

Network services and virtual space, including security aspects

Techniques for the production of specialist software, eg. for appliances.

The needs for social science and humanistic research are related above all to the dissemination of information technology (see "Informationssamfundet år 2000" – 'The Information Society in the Year 2000'). Future changes in the demands on education and on the qualifications of the workforce will influence the conditions under which children grow up as well as their welfare. The possibility of telecommuting and other kinds of more flexible workplaces have implications for the organisation of families and society at large.

Ethical and legal problems will arise in connection with the establishment and use of databases: rights and obligations in connection with encryption and electronic signatures; protection of the individual in connection with medical experiments and the like.

6.7. Research requirements and demands of higher education. Example 4.

In the minds of many, the curricula of higher education institutions and universities are different from other curricula by virtue of being research-based. This view is only partly correct, and it is necessary to analyse the need for research-based curricula and to identify the demands and requirements on the research community with regard to the educational system.

One of the reasons for the move towards drawing up curricula based on research or furnishing them with at least an element of research, is the qualifications and schooling which can be imparted by participation in research. Research represents a generalist qualification which provides the students with a systematic and rational model for evaluating and solving problems.

The desire for a connection between research and education is well-founded. Slightly simplified, there may be said to be three good reasons why there should be a connection between education and research:

Firstly, everybody with an education – no matter who they are, no matter how long the education lasts, and no matter what it contains – must be able to keep alive professionally and to follow developments during their active working years. (This requirement is of course also linked with the problems of further and supplementary education, which will not be discussed here).

Secondly, all teachers – irrespective of their position in the Danish educational system – must be able to keep alive professionally and to follow developments as long as they are teaching.

Thirdly, there is a need for people with an education who know the research system, and have some experience of research or even have been trained as researchers.

We must, however, acknowledge that today not every university student is trained as a researcher, and that neither is this the goal.

The number of people with proper training as researchers must be based on an analysis of society's demand for researchers. In this connection it must be decided whether there is an actual demand for persons with a research-based education, or whether other qualifications are more valuable and more highly appreciated in the labour market. It is necessary to determine the demand for persons with regular training as researchers. As the labour market for trained researchers is (or is on the way to becoming) international, it is essential to ensure that the Danish training of researchers is internationally competitive.

In determining the extent of research that is justified for educational reasons, it is not enough to say that research is part and parcel of university curricula. There must also be, or it must be possible to establish, relevant research in the area. It is necessary to argue for the relevance of the research as such, as well as for its relevance to education.

Individual scientific groupings must be of adequate size if they are to form a solid base for education, training of researchers, and research, and to be capable of quickly and efficiently absorbing new scientific advances.

It is also possible that other factors may be more relevant to education. Research does not form the basis of curricula such as those of the ballet school, the police school and college, and of the education of teachers, some engineers, nurses, and midwives. A considerable part of the teaching of law in universities is performed by persons who do not participate in research, but who have experience in practical legal work.

The conclusion is, that the educational system has requirements and demands for research in those areas where research has a contribution to make, and where this is so important that it must be given higher priority than other contributions such as professional experience and work experience.

It is therefore a large and complicated task to determine the wishes and demands for research of the educational system.

The educational system also has a need for research in education as such – just as the health sector needs research aimed at making it more efficient as well as ensuring quality and development. These wishes are addressed to research in, among other things, pedagogy and didactics.

What can research offer?

7.1. It is necessary to find out what researchers can do and will do

International research shows ways forward

Research, primarily international research explores and shows ways forward. Scientists themselves have an important say in what tasks can and should be taken up. As described in Chapter 6, to imagine that research can be regulated exclusively on the basis of the wishes and needs of society would be a great mistake.

Nor can researchers and research do all that they are asked to do, cf. Chapter 6.1 (page 34). There is a need for dialogue, cf. Chapter 6.2 (page 35).

As a point of departure for this dialogue it is necessary to listen to researchers' own assessment of possibilities and options. In this connection scientists will base their views on knowledge of their own field, on the history and tradition of research, on the structure of research, and the researchers will underscore the strong points. The scientific development of research often opens up new and unexpected opportunities, including opportunities of application. The development and content of research also imply limitations. Research cannot solve all the problems of society.

It is necessary, however, not only to describe the present state of affairs, but also to present an estimate of what the future will offer.

7.2. It is necessary to know where research is anchored

Research of the future is based on present strong points

All research is based on earlier research, even when it explores new avenues. The good research institutions, research groups and researchers that we have are a precondition of progress. Giving an estimate of the future, it is therefore also necessary to indicate where research, and especially the best research, is done today. The strong points of Danish research have to be identified. In particular, they are to be promoted in order to make Danish research stand out.

7.3. Overview and division

Systematisation, not enumeration

A description of the possibilities and opportunities of research does not serve any purpose if it is merely a catalogue; it is not enough to indicate a research area by means of a single scientific term. Again, we shall only be able to make progress by being systematic, accepting all the inconveniences this implies. We shall therefore propose a division of the fields of research.

The division is based on the traditional disciplinary division as reflected inter alia in universities. This is problematic. Research is, admittedly, based on specific disciplines, on scientists' work within their fields. Also interdisciplinary research is based on a solid foundation within the fields involved. The focus of researchers and research is, however, not oriented exclusively towards traditional fields, but also towards subject and problem areas. It is a source of strength in the research community that by involving the necessary disciplines it is able to address a subject and acquire knowledge about it.

What Danish research offers may in principle be structured as shown in the matrix below. The matrix comprises a dimension based on subject areas (the horizontal line) and a field-related dimension (the vertical column).

Subject areas

Fields	Communi-cation	Environ-ment	Energy	Housing	Etc.
Humanities History Linguistics Archeology Etc.					
Social science Jurisprudence Political science Economics Etc.					
Health science Anatomy Epidemiology Neurology Etc.					
Natural science Physics Chemistry Mathematics Etc.					

When considerations are being made in a strategic context as to what research should be given high priority, there are three possible approaches. These are the horizontal approach: choice of subject area; the vertical approach: choice of field; and the cell: choice of a cell where field and subject area meet.

In the above section, society's wishes and needs are considered on the basis of the horizontal dimension: subject areas. This section deals with what research offers in the light of the vertical dimension: the fields. We have chosen this presentation to give an overview, reality, of course, being much more complex. The problem is, as a matter of fact, highlighted in the descriptions of health and agricultural research where the concepts of field and subject constitute an integral whole.

No conclusions can or are to be drawn against the background of the relatively exhaustive description of the individual areas. This is partly because some things may be easier than others to describe in detail, and partly because some things may be more important than others to describe exhaustively.

Strong points are to be identified

In strategy work it is extremely important to indicate the international strong points in Danish research. Strong points should be identified against the background of systematic review and actual analyses of Danish research. As the experience of the consultancy group does not cover the entire research area, we have not given examples of Danish positions of strength in this White Paper. The identification of international strong points in Danish research is, however, a cornerstone of the national research strategy, and our recommendation is that the work of analysis be initiated as soon as possible.

In recent years a number of international evaluations of Danish research, for instance evaluations of environmental research, health research, agricultural research and Danish physics research, have led to the identification of a number of strong points.

7.4. Proposal for framework description of fields of research

1. Humanities

The scientific content of the humanities is reflected in the strategy plans of the Research Council of Humanities, inter alia, which divide the humanities into four principal dimensions: historical, aesthetic, philosophical and linguistic. These retain the characteristic features of humanities research: it explores reality to the extent man participates in it and shapes it materially and symbolically.

The five general universities are the home of much humanities research in this country. Significant work is, however, also carried out in museums, archives, libraries and business schools.

It is a characteristic feature of this area that new research is often immediately applicable in education and that research and the communication of research often go hand in hand.

In Chapter 7.5 (page 57) there is an example of a forward-looking description of the language area.

Special mention should be made of theology. Traditionally, theology is not part of the humanities but is often discussed as if it were, if for no other reason than a wish to simplify matters. It is an open question if theology is part of the humanities today and if theologians themselves perceive the situation as being such. We shall not decide the issue, merely draw attention to the fact that there are faculties of theology at two of our universities.

2. Social science research

Social science research comprises inter alia jurisprudence, economics, sociology and political science.

Social science research is carried out at the five general universities, at the business schools and to a limited extent at the Technical University of Denmark and the Royal Veterinary and Agricultural University. Social science research is also conducted at the National Institute of Social Research, the Local Government Research Institute, the Centre for Development Research, the Institute of Agricultural Economics, the Institute of Regional Studies, the Danish Border Region and other Government research institutes.

Social medicine is based on the theories and methods of social science research to a high degree.

In a number of natural science, technical and health science areas there is a need for social science research. Therefore social science research is carried out in connection with other research.

3. Natural science

Natural science comprises biology, geoscience, chemistry and physics (together with astronomy).

Natural science research is performed at the five general universities, not only at the natural science faculties, but also at the health science faculties. Science research is conducted at the Technical University of Denmark, the Royal Veterinary and Agricultural University and the Royal Danish School of Pharmacy. Natural science research is also carried out at a considerable number of Government research institutes.

Natural science is used as a significant part of the foundation of health science, agricultural science, technical science and environmental research.

In Chapter 7.6 (page 59) there is an example of a forward-looking description of the physics area.

4. Technical disciplines

The technical disciplines comprise a considerable number placed at the Technical University of Denmark and the University of Aalborg. The disciplines are based on natural science but have their own tradition and identity.

Technical science research is carried out at many Government research institutes, including Risø National Laboratory and the Danish Building Research Institute. Technical science research is performed at the approved technological service institutes (ATSIs).

5. Mathematics, statistics, computer science and information technology

Grouping these disciplines together may give rise to criticism. It is equally criticizable to place mathematics with natural science. Information technology may be said to rightly belong with the technical disciplines but has strong links with computer science.

Under all circumstances, these disciplines are related. They are inter alia applied as the groundwork for or as tools within most fields, including the humanities.

Mathematics and statistics are located at the general universities, at the Technical University of Denmark and at the Royal Veterinary and Agricultural University. Statistics is located not only in the natural science, but also social science and health science faculties. Computer science and information technology are placed at the five universities, at the Technical University of Denmark and at the business schools.

In Chapter 7.7 (page 61) there is an example of a forward-looking description of computer science and information technology.

6. Health science

Health science research focuses on health, disease, prevention, treatment and care. The method basis is comprehensive in that it covers natural science as well as social science and the humanities. In a discipline-based division there is little point in distinguishing between medical anatomy, biochemistry, cell biology and physiology and the same disciplines within natural science.

There are a number of health science fields which, irrespective of the fact that they are based on natural science, technical or social science disciplines, have their own identity.

These disciplines are naturally studied at health science faculties and at the Royal Danish School of Pharmacy, but also within the hospital

community and at a number of Government research institutes, inter alia the Government Serum Institute, the Danish Institute for Clinical Epidemiology and at the Danish Hospital Institute.

It is a characteristic of health research that it includes a considerable element of so-called field research, that is research taking place primarily at hospitals.

In Chapter 6.5 (page 44) the NASTRA White Paper is mentioned. It presents an assessment of the present and an estimate of the future with regard to a number of the health disciplines.

7. Agricultural research

In a discipline-based division comprising inter alia natural science, social science and agricultural science there will be no fixed lines of division between, for example, general genetics and animal genetics, plant biology and plant nutrition, general economics and agricultural economics. There are, however, both within the veterinary area, plant breeding, animal and food research, a number of independent fields with their own identity. These fields are placed at the Royal Veterinary and Agricultural University and at a number of Government research institutes under the Ministry of Agriculture and Fisheries.

7.5. Linguistics. An example of description, identification of problems, choice and options within the humanities

Language and language communication play a role in all human activity. Linguistics can only cover certain areas and it is therefore necessary to decide which areas are to be central, and which are to be marginal, or have a support function. Considering the humanities as a whole, this provision is necessary to be able to argue which areas various decision makers (the research council, faculty or university as such, or other institutions) should attend to.

It is a national task to prioritise, that is decide whether to cover very specialised areas such as certain aspects of dialect research or a number of small languages which Denmark has little connection with. It must also be decided if coverage means concentration in one place or if also minor fields are to be secured the opportunity of alternative development. Still, a local strategy is necessary to be able to argue these questions on local terms.

A scientific strategy must prioritise in relation to the overall aims and objectives of Danish research which affect the linguistic research area most directly. For linguistics, for instance, the following:

Communication of knowledge: Should we emphasise the communicative, topical, cross-cultural, sociological, and psychological aspects of this field as well as all that relates to language as a tool?

Cultural identity: **Should we emphasise the historical, national aspects of language in the development of grammar, dialects and sociolects?**

Are these mutually exclusive? If the answer is yes, which of the two is to be upgraded? If no, what is to be done for the two to supplement and develop each other?

The answers must take four things into consideration. Firstly, every strategy must be drawn up with a view to including several quality and relevance criteria. Both the highly prioritised areas as well as those of less weight must be of a standard which makes them function as a whole and allows evaluation of quality.

Secondly, the distribution between central and marginal areas is not a rigid hierarchy. It is a weighting which is to allow for dynamics in that it is open for reprioritisation. The strategy should therefore allow for several time horizons. There must be a long time perspective, for example 10 years, during which a particular high prioritisation is upheld with the resources needed. There must also be a shorter time perspective, such as 5 years, within which work is of an investigative and developing nature, which may play a role when a strategy is to be adjusted.

Thirdly, research should be organised so as to allow for maximum contact with other research environments in interdisciplinary connections. There should be no rigid division of labour between the research environments. This means that research must be planned subject to various organisational forms within an institution in order to achieve the most flexible contact with other and diverse institutions.

Fourthly, efforts should be targeted at areas which have or may have an international impact, thus enabling them to encourage and stimulate the other areas. Also specific Danish subjects within language and communication are to be of international standard, both theoretically and methodologically.

Research into languages is primarily performed at the universities. A research strategy for linguistics, therefore, cannot avoid taking into consideration that these institutions have both research functions, and teaching and other communication functions. A research strategy should, however, take its point of departure from the research side, outline policies against the background of general subjects and fields from which the other functions follow. A subject-based strategy for a linguistic research entity may be able to consider the distribution between intra-linguistic subjects (general linguistics; grammar, including theory of grammar and work on specific grammatical problems and the grammar of natural languages; computational linguistics; language history and dialects) and extra-linguistic subjects (communication across language barriers, cultures and sign systems; sociolinguistics,

pragmatics). When assessing which of them are to be emphasised most or if they are to balance, the four considerations mentioned above may be used as parameters. Some areas will have to be excluded, others will have a support function and others, finally, will be development areas. The overall objective is that the most highly prioritised area or areas should prove proactive. The international reputation of Danish linguistics provides a good basis for further efforts. A weighting within the extra-linguistic subjects will provide good opportunities for upgrading the relevance criteria, cooperation with other scientific environments, international contact, multi-pronged organisational forms and funding.

The current strategy will be targeted not only at the development of the highly prioritised subjects, but also assess if the minimum conditions and demands are sufficient to merit further measures, and if the potential development areas remain promising. A strategy which prioritises remains a strategy for the whole.

7.6. Physics. An example of description, identification of problems, choice and options within natural science

Danish physics research is located at institutions which fall into three groups:

The University of Copenhagen, the University of Aarhus and the Technical University of Denmark, all of them with major and important physics environments.

Three research centres or Government research institutes: Risø National Laboratory, the Danish Space Research Institute and the Danish Institute of Fundamental Metrology.

The University of Odense, the University of Aalborg, the University of Roskilde and the Royal Veterinary and Agricultural University, all of them with minor physics environments.

In 1991 Danish physics was subject to an evaluation and review: "Review of Physics in Denmark", Ministry of Education and Research, 1992. The conclusion of the evaluation was that at the three big universities, at Risø and at the Danish Space Research Institute, there are groups of scientists who are among the best in the world, and there are a few whose research is characterised as outstanding. In general the standard of physics research is of international quality.

Denmark participates in formalised international cooperation in physics through its membership of CERN (Conseil Européen pour la Recherche Nucléaire), ESRF (European Synchrotron Radiation Facility) and ESO (European Southern Observatory). It is necessary to make

sure that there is a sufficiently good basis in Danish physics to enable active participation and benefit from participation in the work of these organisations, especially as the membership fees are considerable.

There is a great need for physics research as a basis for the training of physicists and especially new scientists. Physics and physics research are important because physics is part of the groundwork of a number of technical disciplines and because sections of the business community require access to physics knowledge and physics results.

Budgetary stability is a precondition of research into physics as this research is of a long-term nature. It takes time to establish international cooperation and experimental physics needs considerable investments in instruments of long-term utilisation.

The extent to which university teaching is research-based is often discussed. University education in physics is truly research-based in the sense that it is predominantly the responsibility of permanent staff who are under an obligation to do research. Admittedly, much use is made of instructors, including student instructors in charge of seminar-based teaching in relation to lectures during the first part of the programme of study. However, it is the lecturer and the underlying scientific environment that are responsible for the tuition. The second part of the programme of study takes place in small classes and is predominantly the responsibility of scientific staff, who are actively involved in research.

Present efforts cover satisfactorily the most important part areas of physics, with two exceptions. Efforts in plasma physics and materials physics are insufficient and insufficiently concentrated.

The development in physics has been characterised by a considerable degree of freedom of research with regard to the choice of research subjects as well as research methods.

In general, physics needs concentration on few, large, strong environments. There is also a need for continued investment in large instruments if Denmark is to be the natural home of experimental physics at international level. Examples of investments of this kind are "DR3" at Risø National Laboratory and "Lagerringen" at the University of Aarhus.

During the last 6 years the Materials Technology Development Programme (MUP) has benefited applied and strategic research in physics. MUP is the responsibility of two research councils (the Natural Science Research Council (SNF) and the Technical Research Council (STVF)) in cooperation with the Danish Agency for Development of Trade and Industry. A significant effect of MUP has been substantially increased co- operation between public sector physics research and Danish industry.

Basic research benefits from three centres under the Danish National Research Foundation: CAMP, ACAP and TAC.

A considerable number of research educational activities in physics at the universities take place in cooperation with the research centres, Government research institutes and the business community. MUP in particular has led to increased involvement of private enterprises in the training of researchers.

7.7. Computer science and information technology. Another example of description, identification of problems, choice and options

Danish research within computer science and information technology is conducted primarily at the universities and in the business enterprise sector. It is extraordinary that out of a total of 29 Government research institutes, not a single one of them focuses on computer science and information technology as the most important action area. There is also a considerable imbalance between private and public sector activity in the area, activity in the private sector increasing at a speed the public system cannot catch up with.

Denmark cannot be at the cutting edge in all areas of computer science and information technology. It is necessary, however, for us to be a first-rate integral participant in international research within the core areas of this field, especially within the EU. Current core areas may (with the usual reservations regarding overlap etc.) be divided among the categories of *basic research, strategic research and applied research* as follows:

Basic research: cognition; (computer science) logic, verification and formal models for programmes and systems; algorithm and complexity theory; numerical calculations.

Strategic research: systems architecture; programming methodology and programming systems: high performance computing; heuristic techniques (including neural networks); cryptology; imaging; language technology.

Applied research: systems analysis; software technology; multimedia; information systems (including data bases); (tele)communication; sensor technology; information technology in production and products.

It is not possible for Denmark to cover the total area with a very fine-meshed net. Therefore, it is important that groups within the areas we actually cover should also have the necessary qualifications for speedily following up on a breakthrough in a borderline area. History shows examples of this kind of follow-up with Danish research groups within formal language theory, translation construction, multipro-

gramming and systems description, respectively having seized and further developed areas such as formal semantics, programming systems, Very Large-Scale Integration (VLSI) and object-oriented analysis and construction.

During the last five years public sector strategic and applied research in computer science and information technology has benefited from the strategic *Research Programme on Informatics* (PIFT), jointly funded by the SNF, STVF and SJVF (the Agricultural and Veterinary Research Council). Basic research benefits inter alia from the *Basic Research in Computer Science* (BRICS) Centre, which is funded by the Danish National Research Foundation.

It is a characteristic of present public sector research activity in a number of core areas that it is of a very high standard, both in terms of activity and level of quality with respect to basic research. In almost all areas within strategic research we are represented without, however, having any dominant position. By contrast, with regard to applied research the Danish contribution is in general weaker and in some areas Danish presence is hardly noticeable.

The development within computer science and information technology has been characterised by a high degree of freedom of research with respect to choice of research subjects and research methods. Danish spearhead activities are primarily the result of individual researchers having decided to take up the subjects concerned, and succeeding in involving their colleagues.

Danish research is also characterised by a high degree of internationalisation. Within computer science and information technology Danish researchers operate routinely in an international perspective.

University education in computer science and information technology is, like physics education, truly research-based in the sense that it is predominantly the responsibility of permanent staff, who are under an obligation to do research.

The level of research training activity is acceptable but there ought to be more of it, especially in the light of the needs of the business community. There is a noticeable shortage of co-financed scholarships and of participants in industrial research training, the former no doubt due to the shortage of Government research institutes in the area.

Setting up a Danish PhD course programme should be considered in order to make use of the expertise in most university environments which when combined constitutes a good basis for a first-rate, international, competitive training programme. The establishment of such a programme will probably imply a moderate form of harmonisation of the underlying educational systems with a view to operating on a relatively common scientific basis. Harmonisation of this kind will, in

addition, increase the opportunities for national mobility, which within computer science and information technology is just as limited as in other areas.

8 The international dimension

8.1. Non-formalised international research cooperation

The necessary internationalisation demands greater effort in Danish research. The administrative barriers in the way of foreign researchers and post-graduate students working in Denmark, as well as Danish researchers working abroad, must be dismantled. Research institutions and other decision makers in the research community must prioritise internationalisation. This calls for freedom of action and thus unearmarked grants as well as mobile resources within the research community.

No charity in international research cooperation

As indicated in Chapter 4.7 (page 23) research is often international. Research comprises both cross-border cooperation and competition, and cooperation is both formalised and non-formalised. It is international research that sets the quality standard. There is no charity in international research cooperation. Danish researchers are involved in the co-operation if they have something important to contribute and if they make an active effort. If not, they will be left to themselves.

Researchers are involved in cooperation if they have something to contribute

Internationalisation does not come automatically, but demands active efforts on the part of Danish researchers. For this reason, internationalisation must be an objective of the national strategy, and the Danish research system must establish the framework and allocate the necessary funds to reach this goal.

Danish research performs well internationally as a result of considerable efforts in many parts of the Danish research system. However, Danish research ought to perform even better and although the international level in Denmark is good, the country's limited size and research volume make it imperative to make a special effort. Small countries are more in need of internationalisation than big countries.

Foreign researchers are not queuing up to spend long periods of time in Denmark. It is not a particularly attractive country and a stay in Denmark is seldom enough for the best international researchers. It is not only or primarily a question of money. Top researchers do not want to waste time regardless of whether they are paid for it or not.

Barriers which make it difficult to attract foreign researchers to Denmark must be reduced as much as possible. This is not only a question of making systems transparent. Questions concerning taxes, pension, residence permits, housing and many other issues must be answered quickly and clearly.

There is a wish to attract young foreigners to Denmark to give them a research training here. A precondition is that our PhD programmes should be competitive, that it should be possible to complete such a

programme without any knowledge of Danish, that universities and researchers should be interested in attracting young foreigners and that the administrative barriers should be overcome.

There is also a wish to send Danish researchers abroad. Again, this demands special action. And again, administrative barriers must be dismantled as much as possible.

The Danish research system must not differ too much from what exists elsewhere

Participation in international cooperation develops most smoothly if the Danish research system does not differ significantly from that of the cooperation partners. This makes demands on the structure of Danish education, including researcher training, on the job structure and on the allocation structure. Furthermore, it is necessary to have a good knowledge of languages both for those who go abroad and for those who make a stay in Denmark valuable for foreign researchers. The Danish school system has good traditions with respect to language teaching, but experience shows that improving linguistic skills must be a life-long endeavour. Importance should, therefore, also be attached to language qualifications in further education. Not until the language barriers have been eliminated will it be possible for Danish research to contribute seriously to and benefit fully from international research cooperation.

Participation in international cooperation demands resources and the smoothest procedure is that individual research groups' resources are so mobile that they themselves can make commitments. Opportunities for cooperation easily vanish if researchers have to wait months and years for the necessary grants.

8.2. Formalised international research cooperation

Participation in international research cooperation and primarily in EU research programmes demands that the domestic bases should perform well. Danish researchers must participate in cooperation where this country has its strong points. No allocations are given from outside to cover lacunae in the Danish research system. It must be possible to opt in as well as opt out. Decisions on Denmark's participation in international research cooperation must be taken in connection with decisions on the domestic research system.

Danish researchers participate both in research cooperation established on an informal basis and run by the researchers themselves, and in formalised international research cooperation. Danish participation in EU research is of significant importance in this context.

Participation contributes to securing quality in Danish research. Participation means that this country is a member of a community where the tasks cannot, or only with difficulty can, be carried out by individual countries. Participation also implies that Danish researchers are in a position to attract research funds to this country.

The funds from external bodies, especially the EU, are project grants like research council funds. Neither the EU nor international research institutions take an interest in whether Denmark has the research institutions necessary in order to have a share of the project grants. It is a national responsibility that the country's institutions perform well.

Good domestic bases are necessary to be competitive outside the country

The more Danish research wants to play a role in EU research and in other international cooperation, the more important it is that the domestic bases should be in working order. A strong base is necessary to attract funds from abroad.

It is important that there should be coherence between domestic priorities and participation in international cooperation. When Danish research exerts its influence in the EU, it must be based on a knowledge of where this country's research strength lies and on a wish that EU research programmes should benefit Danish research. Danish researchers are faced by a great challenge to secure Danish influence on EU research and to use this influence in a way that contributes to the attainment of the Danish goals.

Participation in other formalised international cooperation such as in CERN, ESO, ESA (European Space Agency), EMBL (European Molecular Biology Laboratory) and ESRF must be based on a knowledge of domestic research in the area. Denmark should participate if there are good researchers in the area or if the area in question is neglected in Denmark and there is a wish to promote this research. Denmark should not participate unless there are Danish researchers who take an interest in the area or it is possible to attract qualified researchers from abroad to develop it.

Danish participation in and thus Danish grants to international cooperation must be seen in connection with domestic priorities. There is a need for an overall strategy for participation in the international cooperation, otherwise decisions will prove too arbitrary and incoherent. The overall strategy must make it possible to upgrade and downgrade. No country can participate in all international cooperation and it must be possible to opt in and out. Decisions here must be taken in connection with those regarding the domestic research system.

8. The international dimension

Offers and demands concerning individual decision-makers in the public-sector research system

9.1. Who are the decision-makers?

The national strategy must include offers and demands that concern four essential groups of decision-makers: Government ministries that are responsible for research funds provided in finance acts; universities; government research institutes; and research councils.

Decision-makers, or actors in the research system, are in principle all those who decide on choices of tasks, uses of resources, frameworks, appointments and so on, which is why there are decisions and decision-makers at many different levels in the research system. The national strategy is naturally not to extend to offers and demands that concern individual researchers and research groups about strategy and planning. The national strategy must, however, include offers and demands that concern the following four important groups of actors in the research community:

ministries that are responsible for research funds provided in finance acts;

universities and university faculties (The 12 Danish universities and other institutions of higher education that conduct research have different structures. Not all have faculties and activities that span the faculties. For this reason no precise directions are given here as to the levels on which the work must be done.);

Government research institutes;

research and other councils and committees with formal powers of decision.

9.2 The national strategy and individual decision-makers

Decision-makers in the research system must draw up strategies for their work. Their strategies should not be part of the national strategy, but must agree with it. Their strategies are to determine goals and their appropriate means; they must contain budgets, alternative budgets if necessary, but based on realistic suppositions. Strategies cannot be merely non-binding declarations of intent or lists of wishes. The research community must make room for com-

petition but budgets must be determined in an interplay with subordinate and superordinate authorities. Moreover, the decision-makers must be engaged in a discussion of how wishes and needs established in the national strategy are to be realised.

The individual decision-makers must draw up their own strategies

The national research strategy should give a general framework within which decisions are to be taken. The national strategy is not to be so detailed as to become a straightjacket on the Danish research system. Individual decision-makers should have responsibility and possibilities of making decisions.

But the individual decision-makers are to be fully aware that they are working within and contributing to an entity. They should realise that all research has goals, and must determine their own goals.

The decision-makers must therefore work out and use their own strategies that must agree with the overall strategy and be an essential means of carrying it into effect.

The individual decision-makers' strategies shall determine goals and the means to be used to reach them. They cannot be merely non-binding declarations of intent or lists of wishes.

The strategies must build on budgetary expectations. It must be possible to include both basic budgets and budgets for external funds, including allocations from research councils, programmes, the European Union and other sources. There must be possibilities to make proposals for new activities, and to show what can be reached within different budget preconditions. The strategies should be capable of use, and be applied, in negotiations over budgets, and in decisions on the use of budgets or resources.

Research has a need of stability, including budgetary stability. Simultaneously it needs an ability to change and mobile resources (cf. Chapter 11.4, p. 86). At the same time, the strategies must be valid for many years. The frameworks and stability of budgets can be part of the general strategy. Budgets and budgetary stability can also be part of individual decision-makers' strategies, but only within the frameworks determined by superordinate bodies. If not, they are just wishes.

The research system must make room for competition, including competition between research institutions and research councils. Individual decision-makers' strategies should therefore not be made uniform or approved. The national strategy is not a single, great master plan for all public-sector research in Denmark.

But it is self-evident that, between superordinate and subordinate authorities, an interplay will be needed in determining budgets. It will also be necessary to draw individual decision-makers into a discussion as to how wishes and needs determined in the national strategy can be accomodated.

It is also worth emphasising that not all decision-makers have use for formal strategies or can advantageously spend their time on them. Individual researchers, research groups and their leaders make many important decisions. It would be wrong to force them into a process of developing strategies, although many would find this process valuable.

Many of the vital groups of decision-makers have strategies, and some have many years' experience of work with strategies. This is no place for us, of course, to go through and assess all plans that exist.

As an aspect of the national strategy, it is necessary to make a number of general demands as to the content of decision-makers' strategies; these demands are specified in Chapter 9.3.

Decision-makers, individually, and in groups, have responsibilities, tasks and obligations of particular importance to the Danish research system as a whole. In their strategies, these decision-makers must necessarily take account of the general demands and professional priorities, and also address a number of specific problems. In Chapters 9.4 to 9.7, a number of the problems and questions that concern individual decision-makers are considered. The White Paper's description here is far from exhaustive but it gives a number of examples.

9.3 General demands on the contents of individual decision-makers' strategies

Decision-makers must draw up strategies that take account of the following points.

The strategies must cover goals and the means of reaching them, as well as priorities as to fields and subjects.

The strategies must decide who are the users of the research, and include the means of determining their needs, and of communicating the research results to them.

The strategies must set out how strategy, research budgets and usage of resources are linked, as well as how the necessary allocations are made between stationary and mobile resources (compare in general Chapter 11.4, page 86).

The strategies must include investment policy.

The strategies must give the frameworks for strategic work, including how to collect and use external points of view and those of individual researchers.

The strategies must cover recruitment of researchers.

The strategies must contain plans for internationalisation, or how international research levels and international cooperation can be attained.

The strategies must cover means of ensuring the quality of research and also of ensuring that the results of quality evaluation are transformed into decisions.

It is of decisive importance that the strategies are usable and that they can be used in decisions in the world of reality. Non-binding declarations of intent and lists of wishes cannot replace a strategy.

9.4 Examples of contents, problems and questions in Ministerial research strategies

The Ministry of Environment and Energy (needs research and up-to-date knowledge to be able to do its work).

The Ministry is the relevant authority for three research institutions: the National Environmental Research Institution, the Geological Survey of Denmark and Greenland, and the Danish Forest and Landscape Research Institute. All three have research tasks in addition to monitoring, reports and administrative tasks. It is the goal that the institutions should have basic budgets that provide a foundation for continuous research while, subject to competition, they try to obtain significant research grants for their research programmes elsewhere, both programme funds and other research grants from the Ministry, research-council grants and so on, as well as international research grants.

The institutions are expected to cooperate with Danish and other research institutions, including universities. The goal of this is not that they should become the sole possessor of expertise in their fields in Denmark, but that their research and expertise should have international standing and be a channel for drawing on knowledge from Danish and other researchers. The institutions are expected to take part in training researchers. That part of the institutions' research that basic budgets can finance is to be determined by their directors (including their boards) but subject to consultation with the Ministry and other external actors.

The Ministry's research and report allocations should be used with respect for the need for stability and the need to be able to take on new tasks at short notice. Grants should be allocated in consequence of competition or invitations to tender. The Ministry cooperates with other ministries regarding programmes.

Decision-making processes must be open, and the use of research and report allocations must be openly accounted for.

Participation in international cooperation, using funds budgeted for the purpose, is emphasised.

The Ministry of Business and Industry (that with respect to research and development primarily performs tasks relating to trade and industry policy, including tasks concerning support for developing and transferring technology).

The Ministry has responsibility for the technological service system with the approved technological service institutes. They receive basic allocations to build up and maintain competence, but must otherwise acquire incomes by competing for work from the private and public sectors. The basic allocations are not expected to be enough to finance concentrated, comprehensive research and competence building. The approved technological service institutes are expected to cooperate both with Danish universities and other research institutions and with international bodies, and to enter into international competition, but all within the frameworks of their budgets.

The Ministry is implementing a number of programmes to support the transfer of knowledge to private enterprises. The programmes satisfy both the need for stability and the possibilities of taking on new tasks. Funds are allocated in free competition or through invitations to tender. Decision-making processes must be open, and the use of allocations must be accounted for.

The Ministry engages trade and industry in drawing up and conducting programmes. It cooperates with other Government ministries on research programmes.

The Ministry has responsibility for part of the infrastructure of research and development activity (for example, concerning the patents' system).

The Ministry supports recruitment and education of researchers in the private sectors through industrial-research education.

The Ministry's work is not based on research to any great extent. Research and development is planned within the Ministry, augmented as necessary by reviews, consultants' reports and so on. Under the aegis of the Ministry, the Danish Agency for Development of Industry and Trade conducted comprehensive work of analysis by making a number of resource-area analyses in 1993 and 1994. The Ministry itself, however, neither commissions nor buys research.

The Ministry of Education (the relevant Ministry for the universities, where half the country's public-sector research is conducted. In this respect, it is responsible for an essential part of the Finance Act's allocations to public-sector research. It is also responsible for the link between research and education).

Research at the universities is an essential part of the public-sector research system. It is needed to ensure research-based education, and to meet society's need for knowledge, contingency investment in knowledge, and the training of researchers. University research is essential in ensuring specialist coverage at the national level.

An essential question concerns the basis on which research allocations to the universities should be determined. They may depend on teaching content and needs or be made on the basis of student numbers. They may also be granted following proposals from the universities concerning the content of research on the basis of external assessments of quality and with respect to professional goals and needs for research as part of the national research strategy. A further essential question is the extent to which, within the frameworks for their independence, the universities should be responsible for the use of research grants and the extent to which conditions should be attached to these grants. A third essential question is whether universities should be required to ensure that all teaching be based on research and whether all their teachers be required to devote an essential part of their time to research, or whether decisions on this can be taken within the frameworks for the universities' autonomy.

The Ministry can either assume responsibility for the universities' infrastructure that research makes necessary, or delegate this responsibility to individual universities.

The Ministry is responsible for an important part of the whole research infrastructure, including a number of research libraries and UNI-C, and for communicating research from the universities to industry and commerce. In particular, the Ministry has contributed to the establishment of research parks. (In 1994, the Ministry of Research and Information Technology also established a multi-year programme for the research parks.)

The Ministry can either assume responsibility for training researchers or delegate this responsibility to the universities. In connection with this, it may also consider setting goals for making researcher training more international and thus for foreign students´ access to Danish researcher training programmes.

The Ministry is responsible for financing large-scale construction for universities, primarily buildings. They are of essential importance to research and should be viewed in the context of the national research strategy.

In its own activity, the Ministry relies on, among other institutions, the Danish Institute for Educational Research, which is the Government research institute, and on R & D allocations.

The Ministry of Research and Information Technology (is responsible for coordinating Danish research and development, as well as for a number of research institutions, including Risø National Laboratory;

for the research councils; for an essential part of the Danish participation in international research cooperation; and for an essential part of the infrastructure of research).

The Ministry's overall tasks in relation to research policy are described and laid down in the national research strategy. However, like other ministries, it must formulate a strategy for its research institutions and the research infrastructure it is responsible for.

9.5. Examples of problems and questions that must be addressed in the research strategies of universities and faculties

A university must determine the extent to which it will seek external grants

A university (or faculty) must determine whether it wants solid, research-based teaching in a number of basic subjects, and whether this wish should be a weighty factor in allocating research resources, or whether these resources should be concentrated on areas of highest quality and on areas decisively important to its scholarly profiles.

The universities' basic budgets, or their Finance Act appropriations, must be augmented by additional funds if universities are to be able to conduct front-line research, especially in the costly experimental disciplines. A university's goal can be to obtain substantial grants from research councils, programmes and so on, but this will naturally admit external influence on the university's own priorities. A university can therefore also choose to let its researchers themselves be responsible for finding the external financing they need to be active internationally. A university must decide for itself whether budgetary priorities allow it to seek external funds or whether such financing must cost the university nothing or, on the contrary perhaps, may generate a surplus that can be used for other purposes.

If a university decides that teaching in a number of auxiliary subjects is provided by those who do not do very much research, it must satisfy these teachers' needs of further professional development in some other way .

A university must decide how quality in research may be ensured or reinforced, not only for areas of high priority but for its research efforts as a whole; if this is not done development possibilities are reduced. A set of assessment criteria should be applied here and, in this connection, it should be considered whether future external funding should be one of several measurements of quality.

A university must decide how mobile research resources such as grants for technical assistance and use of premises should be allocated to individual researchers, groups of researchers and departments. One choice is to allocate them permanently, another to do so for periods of 5 years, for instance, on the basis of internal research priorities and regular monitoring of quality.

9. Offers and demands concerning individual decision-makers in the public-sector research system

A university must decide about possibilities of cooperation with Government research institutes and with the private sector.

Finally, the universities must decide the degree and manner in which they will assume tasks that have been determined in the national research strategy. They must make decisions about their contributions to ensuring professional coverage and research results that will be useful to society at large.

9.6. Examples of problems and questions that must be included in the strategies of the Government research institutes.

The approximately 30 Government research institutes and 15 archives, libraries and museums conduct research and naturally work in widely different areas of knowledge. At present, however, there are plans for legislation that applies to all Government research.

The Government research institutes work under different conditions and towards different goals. Of those that work exclusively with research, a few do research only for the research community, while most have important customers outside this community. Then there are institutions that, besides doing research, have important monitoring, investigation and administrative tasks. In some instances, research is only a small, although important, part of the institution's work.

Government research institutes must find their place in the research community as a whole

The Government research institutes must decide about cooperation with other research institutions, including universities; about recruiting researchers; about taking part in training researchers; about the degree and manner in which they will take on tasks that have been determined in the national research strategy, and concerning their contributions to ensuring professional coverage.

Statutes, conditions attached to allocations and the like naturally set limits for the right of the Government research institutes to select tasks and utilise resources. Even so it is important that individual institutions consider their place in the national research strategy and their contributions to enabling the national strategy to be achieved.

9.7. Examples of problems and questions that research councils' strategies must include

Research councils must define themselves in relation to the rest of the research system

The research councils have taken the lead in creating strategies. In the strategies they draw up, they have made decisions about contents and to some degree also about choice of measures. They have only defined themselves to a limited degree, however, in relation to the rest of the research system.

A research council tries to realise its own strategy by, among other things, active interplay with research institutions while, through its grants, the council also helps others to realise their strategies. With its marginal grants, the council influences the use of much larger resources and in this way obtains the most research for its money.

A research council must consider, however, the extent to which it will solve problems caused by others. If it always does this, it reduces its chances of realising its own strategy. It can be problematic if a research council uses substantial grants from the point of view that all who receive salaries as researchers and can do good research shall be so funded, if not by others, then by the council. It can also be problematic if a council uses substantial grants to help researchers who, regardless of their qualifications, have been unable to obtain permanent employment or a salary from another source.

A research council must consider to what degree it wishes to contribute to partial financing. While partial funding saves money for the individual grant body, at the same time it causes problems of placing responsibility and complicates processes of making decisions.

A research council must consider the length of time and size of the grant, and also the right of the recipients of grants to freely dispose of them. Research and researchers need stability, and the researchers need to be able to decide about the use of resources; all this must be considered here.

A research council's strategy must include contributions to researcher training and recruitment, besides proposals for cooperation with other councils. Finally, its strategy must, of course, contribute to realising the national research strategy.

10 The national research strategy and the private sector

Research policy must establish the frameworks for cooperation between public and private-sector research, include the wishes of the private sector in public-sector research efforts, and ensure that the public-sector research system performs the work that is allocated to it in the division of labour between the two sectors.

The private sector must undertake to enter into a dialogue about research policy and to contribute to it with its wishes and needs. This dialogue is essential as a foundation for determining national specialisation and efforts made within the public-sector research system.

So that they can conduct research and development in industry, public-sector graduates and researchers should be educated to international standards. Private companies should cooperate with universities on industrial research training.

The public sector is to put its knowledge, research results and infrastructure and networks of international contacts at the disposal of the private sector which, however, should be prepared to commission more research.

Cooperation on research between the two sectors should be based on concrete, mutually-binding undertakings.

Education is a good that the public sector makes available to citizens without direct charge. Prices for output from the public-sector research system to the private sector should be set so as to further competition and prevent distortion of competition.

One of the high-priority goals of the national research strategy is to contribute to enhancing trade, industry and production.

There is a generally accepted and expedient division between the two sectors' research work. Public-sector financing contributes to putting educated researchers, knowledge and research results, infrastructure and a network of international contacts at the disposal of interested parties. Fresh discoveries within different areas of trade, industrial production, improvements in competitive power and employment arise primarily through the research and development undertaken by private-sector companies. This is highly significant, for private-sector

companies account for about 60% of all Danish research and development work. It is hard to imagine how this work could be done if there was no public-sector research system.

Companies naturally decide their research and development goals and frameworks for themselves: only they can assess what is worthwhile. There is broad political agreement that such activity is desirable and vital to the long-term economic health of Denmark, and that it should increase. Work should therefore be undertaken both to remove conditions that hamper a will to devote resources to research and de-velopment, and to encourage companies to increase such resources.

This implies that, when the national research strategy is taking form, the private sector should contribute its opinions. It is desireable that it then follows the strategy and undertakes the obligations it calls for. These obligations are general in character: in essence, that private-sec-tor actors acknowledge their role as customers of and partners with the public-sector research system. The private sector is a very impor-tant recipient of public-sector research. In research, as in other re-spects, customers are a very important source of knowledge.

The private sector must undertake to enter into a dialogue, to empha-sise its needs and wishes, to make its expert knowledge available to boards, research councils and so on, and constructively to form offers to cooperate on research projects and education of researchers. At the same time, private-sector know-how can give essential, highly useful opinions of and proposals concerning the build-up and content of public-sector research.

No such undertaking, of course, implies that any company's right of making its own decisions, or the decision-making power of any pub-lic-sector institution is infringed.

Trade and industry has a general need for highly qualified employees, as well as a rising need for those with the sort of extensive further edu-cation that can secure access to particular knowledge and research re-sults, state of the art knowledge in particular areas, and to the interna-tional research network. Trade and industry wishes to find qualified partners for specific problems, or to find ways of commissioning par-ticular research tasks. Finally, they have perhaps under-estimated their needs for acquiring further education.

It is, naturally, the companies that themselves do much essential re-search and development that have the most definite demands on pub-lic-sector research and on research-based education. They invariably demand professional educational standards for researchers in given

subjects. Their yardstick is internationally accepted standards, which expresses a wish for the services of young R & D scientists with professional skills comparable with the best graduates that can be recruited internationally. This demand for professional qualifications is complemented by – but can never be replaced by – demands for general qualifications. Normally, no width or combination of professional competence can justify any compromise over an essential professional standard.

It is necessary to include these demands when drawing up a strategy that creates frameworks for research efforts. Not all universities, research institutions and areas of professional competence should educate graduates and researchers who can match those of all other such institutions all over the world. It would be unrealistic to demand that they should all be capable of supplying "research-intensive companies" with suitably qualified graduates and researchers. This necessarily entails national specialisation, resources being devoted to positions of strength, and assessments of contemporary relevance.

We must know which areas of research are particularly important to trade and industry

The national strategy must build on the knowledge of which areas of research are critical to and essential for trade and industry – in Denmark now, and in our time. This calls for firmer dialogue between the private and public-sector research communities. This is not to say that trade and industry should decide what research public-sector institutions should carry out. It is well and widely understood that this would be inexpedient and incompatible with the nature of research and the way private companies plan and run their businesses. This dialogue should instead provide politicians, central administrations and decision-makers in public-sector research with a better understanding of private-sector conditions and challenges. At the same time, the private sector should be ready to cooperate within parts of the public-sector research framework and to be as flexible as need be.

The dialogue should contribute to public-sector decision-makers (compare Chapter 9) more boldly devoting resources to the key areas of national specialisation. Specialisation and priorities cannot be dismissed merely on the grounds of freedom for research: the cost of doing this would be too high in loss of quality and ability to compete. Specialisation and priorities cannot depend to any great degree, on the other hand, on subjective enthusiasm among individuals to do the right work, or their ability to engage others.

Efforts should be made to communicate commercially-useful public-sector research results to the private sector. The public sector is responsible for the technological service system.

Specific cooperation between the private and public sectors is necessary

The private sector should take part in cooperative efforts with public-sector research. There are abundant examples of such cooperation between public and private companies, among them the successful cooperation of the Food Centre with the Technical University of Den-

10. The national research strategy and the private sector

mark and the Royal Danish Veterinary and Agricultural University, which derived primarily from grants from the Food Technology Research Programme and the Microelectronic Centre in the Technical University of Denmark. Without efforts by private companies, these centres would have been meaningless. The private companies have brought them up to date by presenting them with topical problems, knowledge of international developments and technological possibilities and challenges, and by participating in research.

The public-sector research system directly subsidises private-sector research within a number of research programmes etc., by supporting participation in international research cooperation, primarily EU research programmes and EUREKA (the European Research Coordination Agency), by granting tax relief and a number of other forms of support. This support is naturally included in the national research strategy.

The private sector should take part in training researchers (compare industrial research education). This is self-evidently valuable to individual companies; if it was not, they neither would nor should do it. But it is also valuable to the universities and the level of researcher training, and is one factor in making training for researchers relevant.

The division of work between public and private-sector research, mentioned above, also includes public-sector research extending to many research areas, where technological-economic usefulness cannot immediately be assessed. It is important, however, to make clear that no sharp boundary can separate research areas of immediate, private-sector interest from other research areas.

Private companies' interest in areas not directly connected to their own research and development differs from the direct use of results and of the professional competence of newly-qualified researchers. This is more a question of trade and industry using partial results. Usefulness for trade and industry can be such that companies find that independent research work is not worthwhile. It can, too, be a question of generally or culturally useful research, or of value to society as a whole, or to some special sectors of it. There can be grounds especially to draw attention to the value of knowledge and research about language, communication and cultural conditions. A dialogue with the private sector is useful here, too, even if it is not so urgently necessary as in the research areas where major efforts are made in both sectors.

We shall not take a position here as to the extent to which the private sector should pay for what the public sector supplies. Two principles should be maintained: that education is a good made available to society as a whole very largely without direct charge; and, that competition should not be distorted (cf. Chapter 11.5, page 89).

Thus cooperation between the public and private sectors is necessary: both must be ready to contribute and receive. It should be underlined that public-sector research can be valuable for private companies only to the extent that they build up a system that can receive knowledge.

The contents of the national research strategy

In Chapter 5.1 (page 28), we defined what a national strategy is, and gave accounts of the elements such a strategy should contain. The present chapter relates in greater detail the individual elements, including questions and problems to be addressed by individual decision-makers and parts of the research system as part of the work of the national strategy. While Chapter 5 described the national strategy in general terms, this chapter indicates concretely how it should be made operative for the strategic work to have the desired effects.

11.1. Wishes and needs, possibilities and offers, challenges

The national strategy shall to a considerable extent take account of needs and the wishes arising from them with respect to the research system.

It shall similarly take account of fields, areas of professional knowledge and subjects, as well as their possibilities and demands with respect to the research system. This must emphasise international development.

The description of the contents of the national research strategy builds on the definition of the strategy given in Chapter 5, and on Chapters 6, 7, 8, 9 and 10.

In Chapter 5, it is stated that the strategy builds on a balance between society's wishes and needs for research, the possibilities of research and what it offers, and international challenges to the national research system. Chapters 6, 7 and 8 address these questions. In Chapter 12, we explain how these descriptions can be amplified so as to make the necessary foundations for the strategy available.

The definitive national strategy naturally cannot exhaustively describe every need, but it must to a great extent take account of such needs and the demands they make on the research system.

Research, however, builds on the work of researchers in their various fields; the manner and degree of how the development of their work presents possibilities and sets limits.

Thus, the national research strategy cannot be built only on the need of society for research and the results of research, but also on knowledge of the development of research as such. This knowledge includes awareness of where Danish research is strong, where it necessarily

must be seen to participate, and where an investment must be made to obtain the benefits of new possibilities. To a considerable extent, the strategy must take account of fields, areas and subjects, and their significance for the research system. It is vital here first and foremost to pay close attention to the development of research in an international context.

11.2. Objectives, goals and priorities in Danish research

The national strategy must include objectives and priorities; it must also include indications of where responsibility should be located in budgetary planning and the use of resources for achieving goals and putting priorities into effect.

The national strategy shall include specialist objectives and priorities and indications of how they may be complied with

The goals for Danish research must be determined on the basis of a balance between needs and wishes, what possibilities it offers and the international challenges Danish research faces. Decisions must of course be taken at many different levels in the research system. The national strategy as such, however, should contain goals and priorities because if it does not, it is of no practical use, having merely put off all the essential decisions that make it a strategy.

It is important that the strategy should contain not just a description of such goals and priorities but also definitely indicates how they can be achieved. It must propose where tasks will be done and responsibilities will lie, as well as proposing how the agreed goals must affect budgetary planning and utilisation of resources. If this is not done, goals are no more than declarations of intent or unclear objectives which cannot be translated into decisions taken in a world of realities. This would mean that a research system would be maintained where everything was regarded, or at least treated, as being as valuable or important as anything else.

11.3 Contributions by individual decision-makers

The national strategy shall contain opportunities for and demands on decision-makers in the public-sector research system.

Strategies drawn up by these decision-makers shall be included in the assessment that leads up to the national strategy.

The national strategy shall contain offers to and expectations of the private sector.

As explained in Chapter 5, the national strategy should contain offers and demands concerning the most important decision-makers in the public-sector research system. Their strategies should be included in the assessment that leads up to the national strategy.

Chapter 9 contains a description of these offers and demands, as well as descriptions of the strategies that the decision-makers are expected to draw up.

These strategies are necessary as parts of the foundations of the national strategy, while drawing them up is valuable in itself. Once prepared, these strategies are documents of great importance to individual decision-makers and to the authorities who have the responsibility, in particular the budgetary responsibility, for the decision-makers in question.

The national strategy should also include offers to and expectations of private companies that conduct research and development. Chapter 10 contains a more detailed description of this.

11.4. Decisions and budgets

Research budgets are a vital means of giving effect to the national strategy, which should set goals for public-sector spending on research as a whole, including outgoings for sub-areas over several years. In this context, the strategy could contain goals for budgetary stability for research as a whole, and for parts of it. An essential part of budgetary planning, however, derives from parliamentary approval of annual Finance Acts.

It must be possible to take political decisions on priorities by means of research policy.

The national strategy should lead up to or contain an indication of the financial level for both public and private-sector R & D spending.

The research system should employ a two-pronged means of making grants: basic grants and additional funds. The relationship between these two means should be determined for the research system as a whole but it shall not be followed slavishly by individual research institutions and must not prevent them from attracting additional funds. In return, the institutions can demand that any additional funds be granted with complete coverage for all costs.

Additional funds should be given as block grants on the basis of contracts between the source of the funds, the host institution and the research group. The contract should comprise regulations with regard to monitoring of the grant and delivery of a report and should control that the aims of the grant are achieved. The contract lays down the services supplied by the host institution and its obligations, and what it should receive as economic compensation.

A large part of both basic allocations and additional funds may be used for mobile resources. Only thus can the ability to change and the possibilities of changes and making priorities be ensured.

Research allocations are laid down in the annual Finance Act

The frameworks and contents of research are laid down largely through decisions about grants. Approval of the Finance Act, and thus of the public-sector research budget, is important when the national strategy is to be implemented. The Finance Act lays down allocations to research institutions individually, to research councils, to research programmes and so on. The relations between the basic allocations to the research institutions (the fixed part of the two-pronged grant system) and the unearmarked funds, including budgets for research councils, programme funds and other additional funds (the free part of the grant system) are decided in the Finance Act.

Decisions made in Parliament and by Government about grants provide, for example, for allocations of funds between different fields. It must necessarily be politically possible to prioritise and maintain, extend or initiate research that is wanted. There must be political possibilities of furthering wishes by users of research. Research policy therefore also covers objectives and scientific content.

The Finance Act gives considerable discretionary powers to ministries, research institutions, research councils and the like. These rights can, however, be restricted by the text of the Act and annotations. The laws on research institutions, including the University Act, laws on a number of Government research institutes and perhaps forthcoming legislation for Government research, set out conditions for using research funds. Correspondingly, the law on, among other things, research councils, contains limitations on the use of grants. In addition, the ministries individually set limits in relation to the use of research grants.

The Finance Act determines allocations for investments, first and foremost in buildings for research. These concern substantial sums, and these grants must also be determined within the frameworks of the national strategy.

The strategy must set up goals for the sum of public-sector research outgoings and for the outgoings to partial areas over a greater number

of years. In this context, goals on budgetary stability for the whole research area could thus be set up and for partial areas for a number of years, and there can be good reasons for this. But it is up to Government and Parliament to establish these goals when they give their annual approval to the Finance Act.

It is the goal of the national research strategy qualitatively and quantitatively to strengthen Danish research as a whole. In 1993, according to research statistics, the sum of Danish R & D amounted to DKK 15.7 billion, of which DKK 6.5 billion was in the public sector, and DKK 9.2 billion in the private sector. The national strategy should pave the way for or contain a decision as to the economic level for R & D in both the public and the private sectors.

There should be room for both basic allocations and additional funds

The national strategy presupposes a two-pronged allocation system, such as is already known from the basic grants in the Finance Acts, and additional funds for the research institutions. The strategy should include an attitude to the distribution on basic allocations and additional funds. On good grounds, the divisions differ for different institutions and types of institution. Demands that the additional funds may comprise only a limited part of the budgets of the research institutions must not lead to limitations in individual institutions' wishes to obtain additional funds. A possible demand must not lead to the institutions declining additional funds, or mean that basic grants to the institutions should be raised if large additional funds become available. On the other hand, demands should be made that additional funds do not burden basic allocations, and that therefore the additional funds fully cover costs for the research to which they lead.

Decisions about the basic grants must be made on the right of disposal of the institutions and on the influence that is accorded to ministries and boards. There may be differences for different institutions and types of institution. But there must also be similarities if the Danish research system is to constitute a unity.

In the case of the additional funds, decisions must be taken about the conditions for allocating them to the research institutions, for the length of time and size of the allocations, and for the rights of disposal and obligations of recipients and donors. It would be desirable if additional funds were given as far as possible as block grants subject to contracts between donor, host institution and research group. Contracts should include regulations for following up on allocations, submitting reports, and controls to ensure that grants achieve their aims. They should lay down what host institutions should supply and do, and what their economic compensation should be.

It is necessary that decisions on all levels of the public-sector research system should be in agreement with the national strategy. At the same time, it is necessary to have a high degree of flexibility and rights of dispoal when drawing up budgets and in utilisation of resources.

It is a central problem concerning research allocations that some resources are stationary while others are mobile. Stationary resources include, for example, salaries to permanently employed people, buildings and rights of occupancy of buildings. There is a tendency to view a large proportion of grants to public-sector research as stationary. But if the research system is to have an ability to change, and if there are to be possibilities of regulation and of making priorities, mobile resources are necessary. Mobile resources can be acquired if resources that are generally considered stationary are treated as mobile, and it can be done by supplying new resources. Resources do not possess qualities that are either stationary or mobile, but are the one or the other by virtue of decisions.

11.5 Frameworks and structures

The national strategy shall in part concern itself with overall frameworks for research, and in part with demands on decision-makers for frameworks.

Government research institutes should both perform tasks that are specific to sectors, as laid down in cooperation with the ministries responsible, and contribute to the general Danish research level and our contingency investment in knowledge in general. There should also be room for basic research in sectorial research.

Within frameworks to be more closely defined, universities should be able to accept responsibility for research that is necessary on account of specific demands in society as a whole, including needs determined by ministries other than the Ministry of Research and Information Technology and the Ministry of Education, and by other authorities.

The possibilities for cooperation, including shared use of buildings and equipment, between universities and Government research institutes, should be made use of, and this principle should have an impact on decisions on outgoings for research facilities.

The universities have responsibility for the international quality of researcher training, and thus for supervising post-graduate research and awarding doctorates and PhDs. Other public-sector research institutions should be engaged in researcher training to the greatest extent possible. The private sector should also be invited to take part in researcher training.

Possibilities should be improved for the mobility of researchers between different research institutions, including universities and

Government research institutes. There should also be access to arrangements for exchanges and moves. The researchers should have possibility of and support for scholarly development. The terms of appointment and work for researchers should take necessary account of academic freedom.

The job structure and conditions of employment should make it possible to pursue an active, goal-orientated recruitment policy in all parts of the research system.

Danish research shares a common infrastructure which includes the library and documentation system, the computer network, special and costly equipment, and so on. The infrastructure is at the disposal of the entire Danish research system, including private-sector research. At all times, the location of responsibility for the different parts of the infrastructure, and for the infrastructure as a whole, should be clearly visible. No public-sector research institution may build up and maintain an infrastructure for its own exclusive use, if other parts of the research system want or need access to it, and if it has spare capacity.

All public-sector research should be communicated and used

As far as possible, all public-sector research should be communicated and used. The research system should be presented externally in comprehensible form, and there should be easy access to expert knowledge. The private sector should be able to draw on research and expert knowledge from universities, Government research institutes and technological service institutes, solely with respect to which of them can supply what is wanted. Uniform price-setting rules for all public-sector research institutions and all research institutions supported by public funds should therefore be aimed at.

Frameworks for research are not merely allocations. Legislation and administration lay down many other framework conditions for research. Some diverse examples include rules on the job structure and on appointments, and working environment legislation. In addition, political and administrative decisions in other areas can have great importance for the research system. Some more diverse examples include agreements with trade unions, legislation pertaining to public servants, and taxation legislation, in particular taxation provisions applying to aliens or to Danish citizens living outside of Denmark.

Frameworks of research also include regulations as to communication and marketing of research and the influence on research of its users.

11. The contents of the national research strategy

No overview can naturally be given here of the political and administrative frameworks for the research system. But a task for the national strategy and for research policy is to ensure that a sensible entity emerges from this multiplicity.

It is not a task for the White Paper to put forward proposals for the structure of the research system and therefore, for example, for the delimitation of remits, structure of councils and divisions of competence. The White Paper's proposals are valid, however the research system is structured and may be changed.

Division of labour
and cooperation

The overall frameworks should include an attitude to division of labour and cooperation between different types of institutions. It is not enough that individual Government research institutes have individual objects clauses. It is desirable that they should not merely perform specific sectorial tasks, but also contribute to the totality of the country's preparatory investment in knowledge. A number of Government research institutes must necessarily contribute to basic research and thus to developing international research, not merely depend on research at universities and abroad.

It must be specified how far universities should be able to make their research capacity available to meet the need of society for immediately applicable research. To a certain extent, it would be desirable to make universities responsible for such research.

Cooperation between different research institutions, particularly between Government research institutes and universities, is desirable in general and necessary in a number of instances. Necessary or at least very valuable cooperation is exemplified by that between the medical faculties and the university hospitals, and that between the Department of Geology and the Mineralogical Museum of the University of Copenhagen and the Geological Survey of Greenland (soon to be between the university and the new Geological Survey of Denmark and Greenland). In allocating programme funds and other additional funds demands are made in a number of cases for cooperation between institutions.

It is important that the possibilities for such cooperation should be taken account of in making decisions about investments in buildings.

Researcher training

The national strategy should address the question of researcher training which, as a matter of importance, should be of international quality. It is also important that the whole research system should contribute to researcher training: outside the universities, great potential exists that can contribute to researcher training, while research institutions and groups of researchers would benefit from young people joining them, posing questions, and making proposals and demands. Especially in private-sector research there is large potential and need for participation in researcher training (compare industrial researcher training).

The national strategy should also make decisions about researchers as individuals. It is necessary to lay down demands for change, development, mobility and conditions of work. It is necessary to lay down demands for recruitment on all levels in the research system. The present regulations for permanent employment of university teachers can make it very hard, if not simply impossible, for the universities to pursue an active, goal-oriented recruitment policy. The job structure itself can also cause problems. It is therefore desirable to include conditions of employment and job structure in the national strategy. It is also desirable to achieve much greater mobility in the research community, including that between university researchers and researchers in Government research institutes.

Research has an infrastructure that among other things includes research libraries, documentation systems, computer networks and special, costly apparatus. It should be apparent from the national strategy that the responsibility for this infrastructure and for its development in response to national and international demands must be clear. The infrastructure must be at the disposal of the whole research system, including private companies. Corresponding to this, individual research institutes should not build up and keep to themselves an infrastructure that others can be interested in using, if it has capacity that they can utilise.

Research results should be communicated or marketed. This implies demands on individual ministries, research institutions and so on. But there is also a need for overall frameworks for communication and marketing. All public-sector research should be accessible and the research system should be clear, so that there is easy access to expert knowledge.

In this context, the relationships between universities, Government research institutes and the technological service system should be included. In general, the goal should be that the whole of the public-sector research system can be drawn on. No-one should have a monopoly of dissemination to the private sector. Utilisation of the public-sector research system should be decided by whoever can deliver the desired results with the right quality. But prices for services from the public-sector research system must be laid down, so that, for example, the approved technological service institutes are not exposed to unfair competition.

11.6. Quality and quality evaluation

The national strategy shall lay down frameworks for evaluating quality and for incorporating quality evaluations in decisions.

11. The contents of the national research strategy

It is necessary that responsibility for conducting quality evaluations and ensuring they have consequences is clearly visible throughout the research system.

Research with a quality on an international level is decisive for research being able to perform its tasks satisfactorily. Quality does not come by itself, and evaluations of quality are as necessary in research as elsewhere.

The strategy should therefore make demands for evaluations of quality, and it is important that several evaluation criteria are employed. Not all criteria suit all subjects and research tasks, and quantitative accounts of research activity cannot be decisive. But quality evaluations *We cannot make our* must not lead to a large new bureaucracy. The system must be experi- *living by evaluating* enced by individual researchers as meaningful and transparent; we *one another* cannot make our living by evaluating one another.

Quality evaluation has value, however, only if statements that quality is absent lead to decisions about changes. For this reason, it is essential to bring together quality evaluation and the system of making decisions. There are many different possibilities for doing something if quality is not satisfactory. In general, positive action, or action to improve quality, is of greater value than negative action, for example, in the form of dismissals or discontinuing institutions, institutes and research groups. The most harmful is, however, if declining quality does not lead to action of any sort.

11.7. Research ethics

The national strategy should ensure that necessary emphasis be given in all areas of research to ethical problems

Research in the health sector raises a number of ethical problems. For a number of years, researchers have been able voluntarily to obtain services and advice from a system of scientific ethical committees, which they are now required by law to consult. A revision of this law is in preparation at present.

These committees do not undertake, however, to address all ethical problems arising from health research. No corresponding system exists at present in other research areas. It is necessary as part of the national strategy to ensure that ethical questions are considered and addressed in all research areas.

11.8 Coherence and openness

The national strategy shall contain overall goals and frameworks for research, including frameworks for how goals are to be determined, and decisions taken in research administration and within the research system.

The national strategy should ensure an open, coherent and transparent research system, and a discussion about research policy that contributes to the basis for decisions in the general policy for research and research administration.

No detailed goals nor regulation of tasks should or can be superimposed on research.

The task of the national research strategy is to create coherence in our research system, and in all the decisions that have influence on the research system. We need a transparent and relevant research system with clear procedures for decisions. This means that responsibility and decisions must belong together.

Discussions arise but not spontaneously

Research policy can be formulated only on the basis of a discussion that engages politicians, administrations, research institutions, researchers, users of research and others. This discussion will not begin spontaneously. It is therefore a task for the national strategy to create the frameworks for the necessary discussion, to ensure that it takes place, and that contributions to it come to be utilised as part of the basis for decisions in general research policy and the research administration.

Research, research policy and research administration have goals on many different levels. Research itself has goals. Research institutions, research councils and the like have goals. The goals that must be determined in the national research strategy and in research policy are overall goals. It is neither possible nor desirable to superimpose detailed target and task control from above.

11.9. Adjustment and renewal

The national research strategy should contain indications about work during coming years to adjust and renew the strategy.

Work will not be over once the national research strategy has been approved in 1996. The strategy must constantly be revised and renewed. The strategy cannot settle everything once and for all: research is a dynamic process and society changes. There will be a constant need for

changes and alterations of course, while both stability and continuity will be essential. Precisely for this reason, it is necessary to have an overall strategy: if it exists, changes and alterations of course will not be more or less arbitrary, unexpected and sudden.

The strategy should also contain proposals for further work. Revisions must be conducted over a longer time than has been taken to work out the original strategy, for example, with respect to the adoption of a new strategy in the year 2000.

Subsequently, work on strategy could be conducted within firm frameworks, with renewal taking place every third or fourth year.

How can we progress from here?

12.1. The first national research strategy and continuing strategy work

The Government has decided to adopt a national research strategy in the summer of 1996 and in the following we suggest how this objective can be achieved.

The work on research strategy does not end there, however; on the contrary, from then on the process must be one of continual adjustments, cf Chapter 11.9 (page 94). It is too early to make elaborate plans and set up a framework for future work as this must be based on experience from the elaboration of the first strategy.

The conclusion of the discussion regarding this White Paper and the decisions regarding further work on the strategy must be taken by the Government. The Ministry of Research and Information Technology is responsible for all the following steps which we suggest in the rest of Chapter 12 as a part of future strategy work

12.2. The objectives and the form of the national strategy must be determined from the beginning

In Chapter 5 we presented our view of what a national research strategy is. In this connection we suggested that the strategy should cover:

overall objectives for Danish research (Chapter 3);

the establishment of society's wishes and needs for research results (Chapter 6), the possibilities of research and what it can offer (Chapter 7), together with the challenges in the research field created by international developments (Chapter 8);

offers to and demands on all important decision-makers or actors in the research world, including ministries, research councils and public research institutions (Chapter 9), and private firms who carry out research and development (Chapter 10);

the establishment of objectives and priorities for Danish research together with a plan for how these objectives can be achieved;

the establishment of the connection between strategy and decisions in the research system, research administration and research policy (Chapter 11);

demands with regard to the research system's framework and structure based on an understanding of what research is and what its objectives are (Chapters 4 and 11);

a suggestion as to how a continual adjustment of the strategy can be organised.

The national research strategy must be seen in the light of the strategies drawn up by the individual decision-makers, including ministries, universities, research institutions and the research councils.

If a national research strategy is to be ready in less than a year, then its form must be established without delay. Adjustments can and will probably be made along the way. However, there must be no basic doubt or discussion concerning the nature of a national research strategy throughout the whole process.

It is therefore necessary to decide at an early stage which elements are to be part of the national strategy.

12.3. Everyone cannot and should not be consulted regarding all aspects of the discussion.

The national strategy must be established through discussions and hearings and this process will be chaotic if a framework for it is not established. Not everything can be discussed continually and in all fora.

We therefore suggest that the discussion be divided up into three themes:

the overall objectives of research, research itself and the framework and structure of research;

society's wishes and needs regarding research;

the possibilities of research and what it can offer.

This process could be conducted as three separate discussions.

12.4. The discussion of overall objectives, research itself and the framework and structure of research

The White Paper could constitute the basis for this discussion. It would be desirable, however, as a basis for discussion if the Government also were to comment inter alia on the relationship between project and programme funds and basic allocations, on the question of budgetary stability, and on the question of the autonomy of the research institutions.

Those who participate in this discussion must be all who have an interest in research and research policy. In particular, universities, research institutions and the research councils must be involved.

12.5 Discussion concerning society's wishes and needs for research

The White Paper's proposals do not provide a sufficient basis for a discussion on this particular point. It will be necessary to further develop the description in Chapter 6 and to involve the necessary professional expertise.

Setting up a series of working groups could be considered, each of which consists of 2 or 3 members who could elaborate on the description in brief reports (of about 10 pages each). This would require agreement on a division such as that given in Chapter 6 very early in the process.

Again, everyone must be allowed to participate in the discussion (or the many small discussions). However, it is important to make sure at the same time that individuals, institutions, ministries, firms and organisations with special knowlegde or special interests are involved. The best result would be reached if not everyone participates in everything, but if the participants are present at those discussions where they can really make a contribution.

It will be difficult to conclude this discussion before the end of the year. One alternative would be to postpone the discussion of some areas and simply state in the first national strategy that they must be dealt with later. However, this would result in the first strategy bearing the mark of incompleteness.

12.6. Discussion on the possibilities of research and what it can offer

The description of the White Paper (Chapter 7) must be made more subtle and more thorough. This preparatory work could be done with the help of special experts or the research councils. From then on these could organise the discussions.

It is assumed that the discussions must be based only on knowledge and material which is already available and that, for example, it is not necessary to carry out evaluations to find positions of strength or weakness. This could slow down the work considerably.

The first national strategy will not, on the other hand, contain a comprehensive description of positions of strength.

The final discussion papers must be very limited in size. It does not appear an insurmountable task to have them formulated and to implement a meaningful discussion before the end of the year. The bottleneck will probably be technical. How many discussions, how many meetings can the administrative system cope with?

It is very important that universities, faculties, research institutions, the research councils and most important of all, researchers, should be involved in the discussions.

12.7. The strategies of individual decision-makers

The discussion regarding the research system's framework and structure will lead to the determining of demands regarding the strategies of individual decision-makers (cf. Chapter 9). It is necessary to determine these demands as quickly as possible. If a decision on this should have the desired effect, then a Government resolution will probably be necessary.

A large number of decision-makers have formulated their strategies in the last few years. However, it will be necessary to ask for an adjustment of these strategies in the light of the general requirements that have been drawn up.

It would be desirable that the adjusted strategies are available on 1 March or 1 April 1996 if the aim of a national research strategy is to be realised by the summer of 1996. An overview of all existing strategies could be drawn up as an appendix to the strategy.

12.8. The final scientific contents of the national strategy

On the basis of the discussions mentioned in Chapters 12.4., 12.5. and 12.6, and the strategies from individual decision-makers mentioned in Chapter 12.7, a final proposal can be elaborated regarding the scientific contents of the national strategy with specification as to how the concrete objectives can be achieved. It will be necessary at this point to decide the national specialisation and make the necessary priorities.

The final proposal for a national strategy will be sent for comment to all decision-makers and actors in the research community.

12.9. Externally proposed research tasks

Demands made of individual decision-makers' strategies involve a requirement concerning the establishment of who the research users or recipients are, and concerning the establishment of frameworks for incorporating these in the decision-making process regarding new tasks.

The possibility of carrying out research on the basis of externally proposed suggestions depends to a high degree on the existence of mobile resources, whether these are to be found in institutions' basic allocations or belong to the programme and project funds, cf Chapter 11.4. (page 86).

On the general level the question of new tasks must be taken up in connection with decisions regarding the Finance Act. The proportion of free funds to basic funds for research is decisive here (see Chapter

11.4.). Future revisions of the national research strategy must of course involve the moving of resources and the addition of new resources for new research tasks.

12.10. Public meetings

The Minister of Research and Information Technology has expressed the wish for a number of public meetings to be held in September/ October concerning the national research strategy. We propose that these meetings should be carried out on the basis of the White Paper and that they should centre on the overall objectives, on research itself and on the framework and structure of research (Chapter 12.4.). The summary in the White Paper could be used as a framework for these meetings.

It might be worth considering holding one or several meetings on the interface between public and private research and on the use of public research in the private sector. Such meetings must be held in cooperation with the Ministry of Research and Information Technology and the other relevant ministries.

Finally, one or several meetings on the connection between research and education could be held. Such meetings should be held in cooperation with the Ministry of Research and Information Technology and the Ministry of Education.

Research in Perspective

White paper on a national research strategy

What is research and why do we need it?
How can good research be distinguished from bad?
What do we expect of Danish research?

The Government has resolved that Denmark is to have a national strategy which can enhance the quality, relevance and international dimension of research.

To this end the Ministry of Research and Information Technology charged a group of consultants with the task of preparing a White Paper which addresses the twin questions of what a national research strategy is, and how Denmark can acquire such a strategy.

The White Paper is to form part of the basis for further work in this area. It will be the starting point for wide-ranging debate with a view to drawing up a national strategy for research during the first half of 1996.

A national research strategy is a binding framework for decision-makers in the world of research, including ministries, research councils and public research institutions.